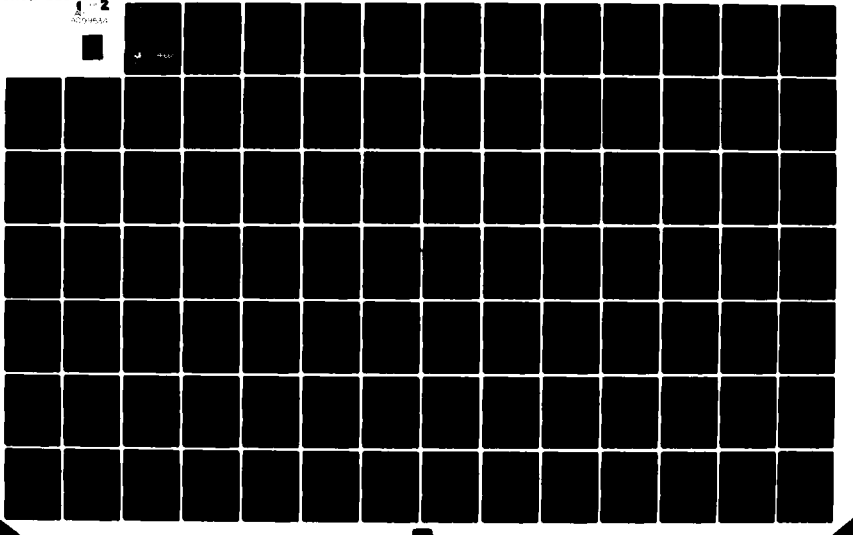
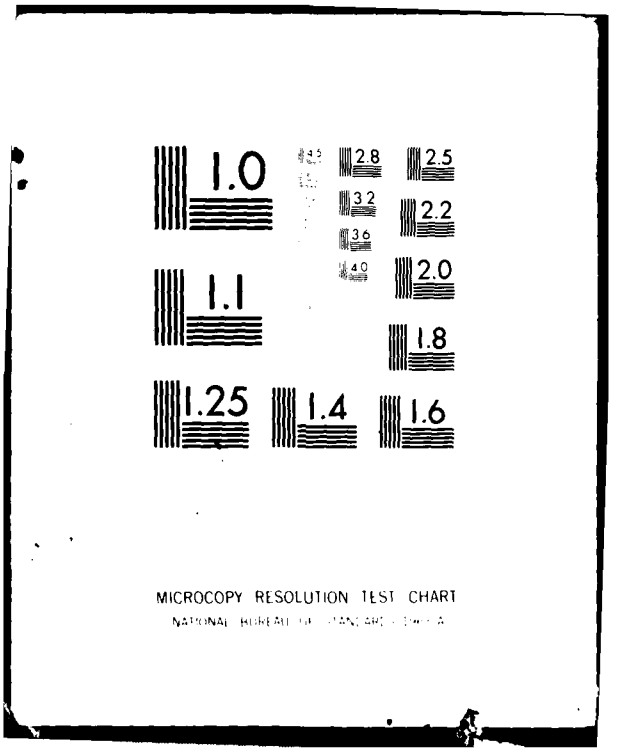
AD-A099 534 AIR FORCE ENGINEERING AND SERVICES CENTER TYNDALL AF--ETC F/G 11/6
PROTECTIVE COATINGS FOR STEEL STRUCTURES: LABORATORY AND FIELD --ETC(U)
JAN 80 P G CAMPBELL, J F SEILER, G A SLEATER

UNCLASSIFIED AFESC/ESL-TR-80-20 NL

1 2




1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

LEVEL II

ESL-TR-80-20

12

PROTECTIVE COATINGS FOR STEEL STRUCTURES: LABORATORY AND FIELD EVALUATION AND DEVELOPMENT OF A MODEL COATING GUIDE SPECIFICATION

P.G. CAMPBELL, G.A. SLEATER, M.A. POST, J.F. SEILER

STRUCTURES AND MATERIALS DIVISION
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

JANUARY 1980

FINAL REPORT
JUNE 1977 - JANUARY 1980

AFESC

ENGINEERING & SERVICES LABORATORY
AIR FORCE ENGINEERING & SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403

NOTICE

Please do not request copies of this report from HQ AFESC/RD (Engineering and Services Laboratory). Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with Defense Technical Information Center should direct requests for copies of this report to:

Defense Technical Information Center
Cameron Station
Alexandria, Virginia 22314

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

REPORT NUMBER: ESL-TR-80-20	2. GOVT ACCESSION NO: AD-A099534
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): PROTECTIVE COATINGS FOR STEEL STRUCTURES: LABORATORY AND FIELD EVALUATION AND DEVELOPMENT OF A MODEL COATING GUIDE SPECIFICATION .	5. TYPE OF REPORT & PERIOD COVERED: Final Report, Jun 77 - Jan 80
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): P.G. Campbell J.F. Seiler G.A. Sleater M.A. Post	8. CONTRACT OR GRANT NUMBER(s): F49642-77-90648
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Structures and Materials Division, National Bureau of Standards, Washington, DC 20234	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Program Element: 63723F JON: 21045C0Z
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Engineering and Services Center, Tyndall Air Force Base, Florida 32403	12. REPORT DATE: Jan 1980
	13. NUMBER OF PAGES: 100
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Availability of this report is specified on verso of front cover.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Coatings, Corrosion Protection, Paint Specification, and Paint Inspector's Guide

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The effectiveness and durability characteristics of ten specially selected coating systems were evaluated using laboratory and outdoor exposure testing techniques. Test emphasis was placed on testing combinations of coating materials that could protect high value steel structures. Additionally, the authors have written a model coating guide specification. This specification, when combined with a special Paint Inspector's Guide that was also developed as a part of this project, will help coatings specifiers select proper coat-

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 394632
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (CONCLUDED)

ing systems based on the existing nature and condition of the surface to be coated. The Paint Inspector's Guide is included as Appendix A to this report. It can be used by paint inspector's to help characterize paint failures and to advise paint inspectors when overseeing painting applications.

PREFACE

This report summarizes a study conducted by the Structures and Materials Division, National Bureau of Standards, Washington D.C. 20234 for the Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, Florida 32403.

This report is written to assist painting inspectors and engineers at all levels of command who have responsibility for developing and executing painting contracts.

This report is the result of work performed during the period June 1977 to January 1980, and was submitted by the National Bureau of Standards to AFESC on 31 January 1980. This document summarizes all work accomplished by the National Bureau of Standards under contract F49642-77-90648 and this document has been reviewed by members of the Maintenance and Research and Development Divisions of the AFESC. The National Bureau of Standards project manager was Dr Paul Campbell. The AFESC project officer was Mr Mike Womack.

Certain commercial equipment or materials are identified in this report in order to adequately specify or test the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards or the U.S. Air Force, nor does it imply that the material or equipment identified is necessarily the best available for the purposes.

This report has been reviewed by the Public Affairs (PA) office and is releasable to the National Technical Information Service (NTIS). This report is available to the general public, including foreign nations, from NTIS.

This technical report has been reviewed and is approved for publication.

ANTHONY J. KWAN, Capt, USAF
Project Officer, Airbase Facilities Branch

L. M. WOMACK
Acting Chief, Engineering Research Division

FRANCIS B. CROWLEY III, Col, USAF
Director, Engineering & Services Laboratory

(The reverse side of this page is blank)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

(The reverse of this page is blank)

SECTION I

INTRODUCTION

1.1 BACKGROUND

Corrosion costs in the U.S. have been estimated to be $70 billion annually (Reference 1) and Air Force facility-related corrosion costs alone have been estimated to be $300 million per year. In an effort to substantiate these corrosion-related costs, the National Bureau of Standards undertook a corrosion survey of all major Air Force installations (Reference 2). This survey found that (1) most facility-related painting failures occurred from the use of oil or alkyd paint systems rather than more advanced systems (see Figure 1), (2) most failures occurred within 3 years after application (see Figure 2), and (3) most failures occurred where hand/mechanical surface preparation was used rather than use of the more costly abrasive blasting techniques (see Figure 3).

Based on this corrosion survey, a map was prepared showing base location and severity of corrosion problems (see Figure 4). A similar map relating corrosion of automobiles has been developed by the American Iron and Steel Institute (Reference 3). There were similarities between the two maps in the severity and location of corrosion even though automobile corrosion would be expected to be accelerated in areas where road de-icing salts are used extensively, e.g., North Central and New England states. Of course, Air Force steel structures would not be exposed to de-icing salts. One specific similarity between both maps is that the coastal areas of Florida and the Gulf Coast were considered to be a harsh environment while the western plains states appeared to have negligible corrosion problems.

1.2 OBJECTIVES

The objectives of this study were:

1. To evaluate, by accelerated laboratory methods, the effectiveness and durability of selected coating materials for steel structures.

2. To evaluate by field test, including test buildings at Andrews AFB, the effectiveness and durability of selected coating materials for steel structures.

3. To develop a comprehensive model coating guide specification.

4. To develop a comprehensive paint inspector's guide to help ensure adequate quality control when inspecting the application of coatings on high value steel structures.

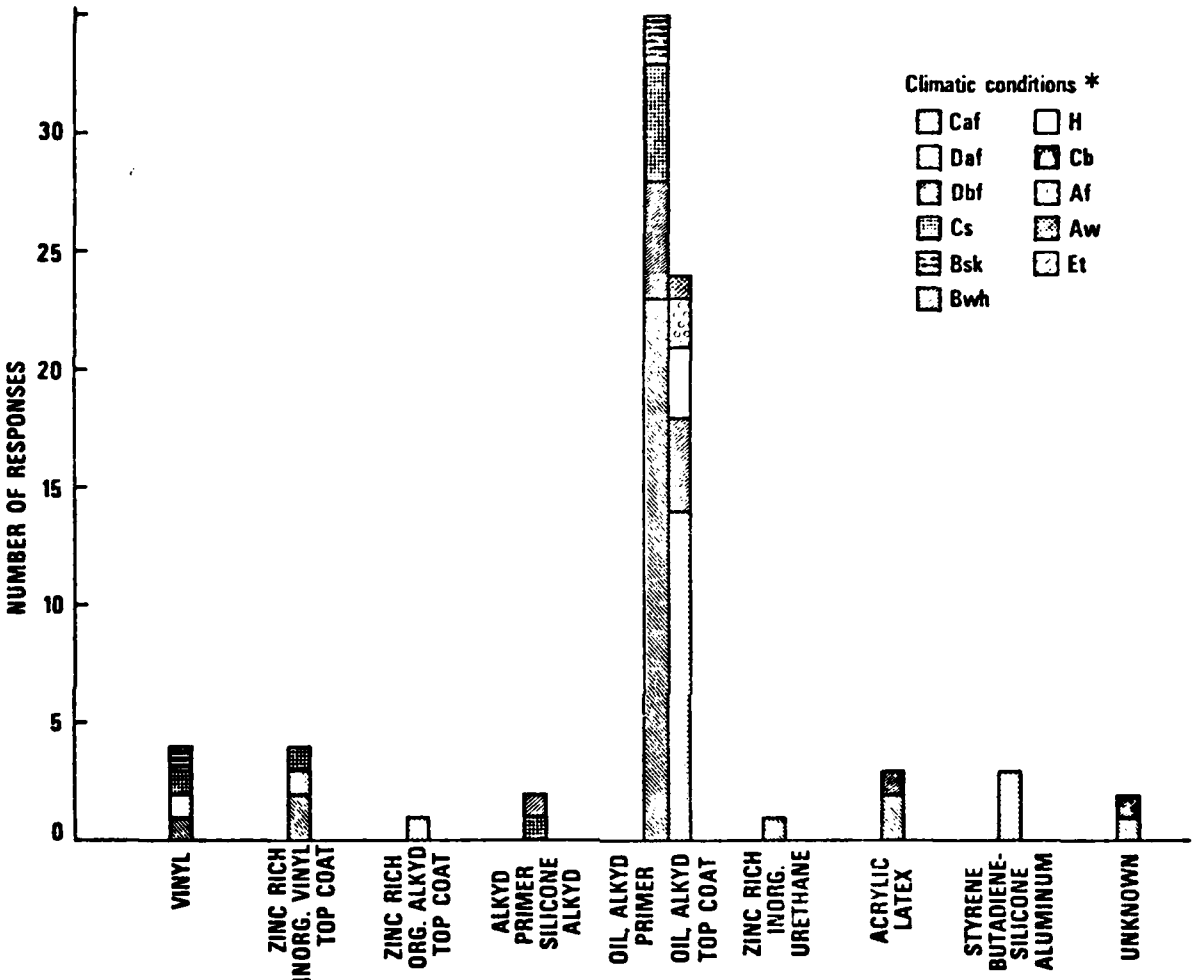


Figure 1.* Coating/corrosion problems versus type of coating system used.* Base climates (after G.T. Trewartha, "An Introduction to Weather and Climate", 2nd Ed., McGraw-Hill Book Co., Inc., New York) are as follows: 31 bases Caf (humid subtropical, no dry season); 14 bases Da_f (humid continental, warm summer, no dry season); 7 bases Cs (mediterranean); 7 bases Bsk (middle latitude desert); 6 bases Bwh (tropical and subtropical desert); 3 bases H (highland); 2 bases Cb (marine west coast); 2 bases A_f (tropical rainforest); 1 base Aw (tropical savanna); 1 base Et (polar tundra); Dbf (Humid Continental, No dry Season, Cool Summer).

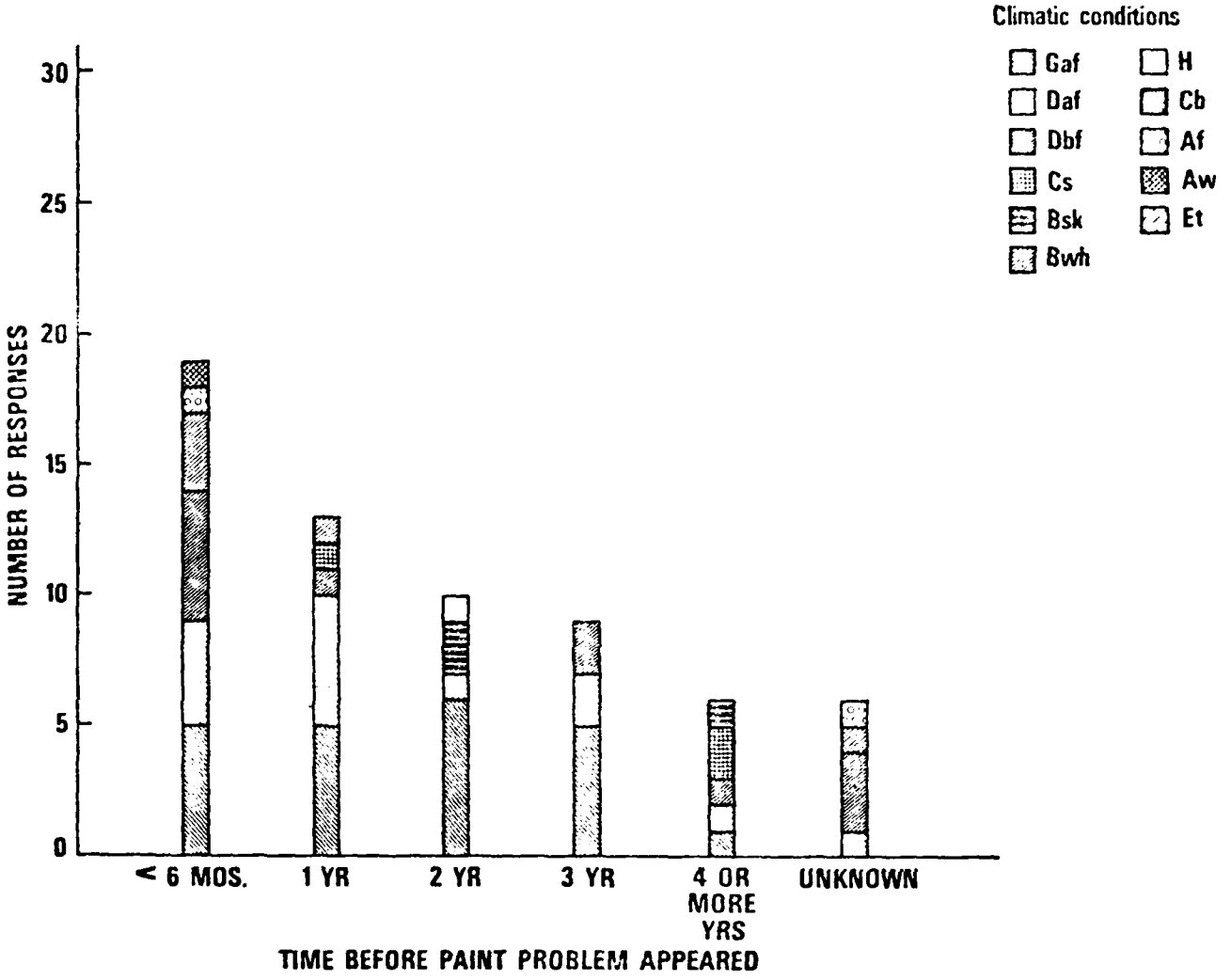


*Figure 2.** Coating/corrosion problems versus time before problems appeared.

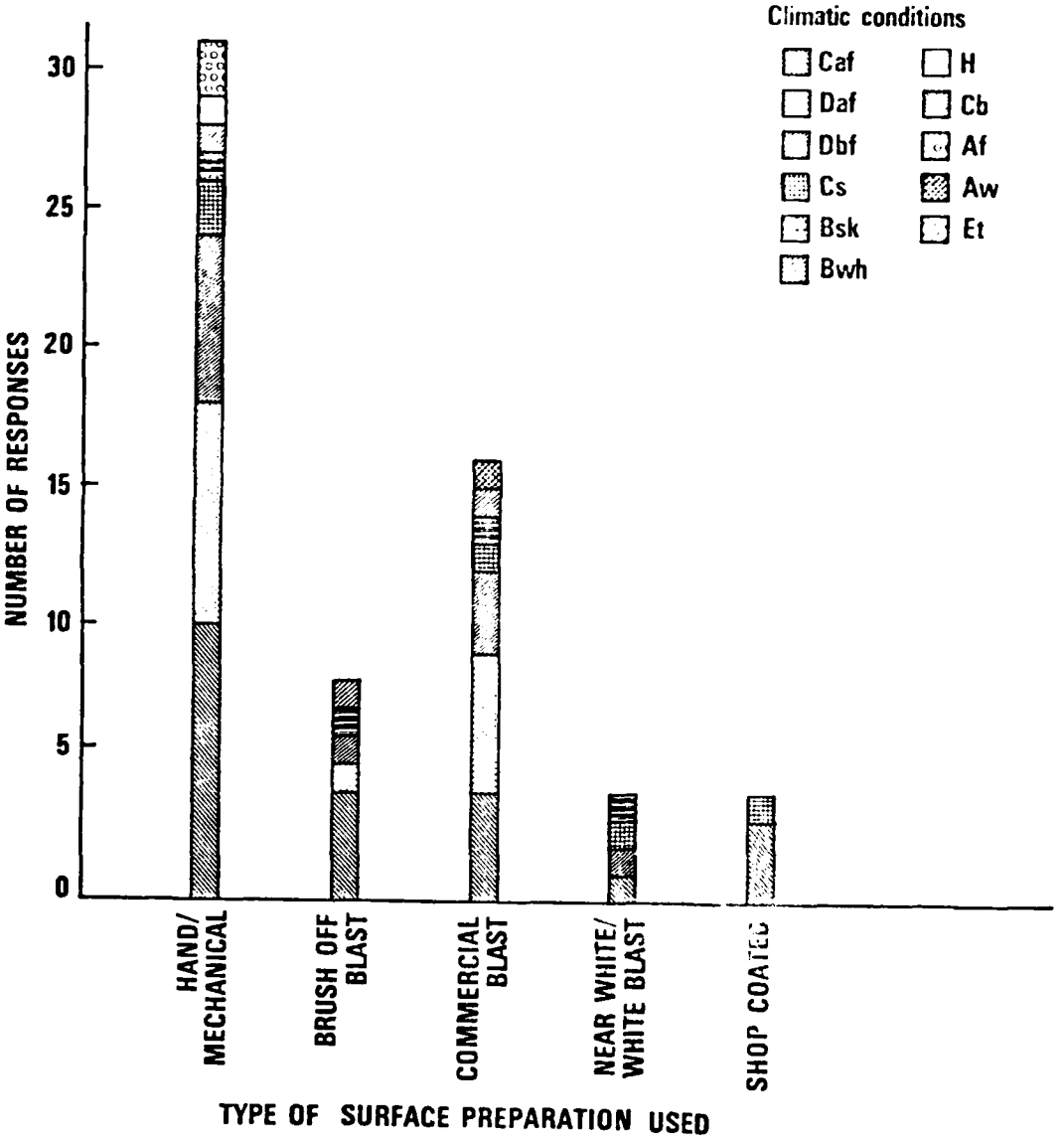


Figure 3.* Coating/corrosion problems versus type of surface preparation used prior to painting.

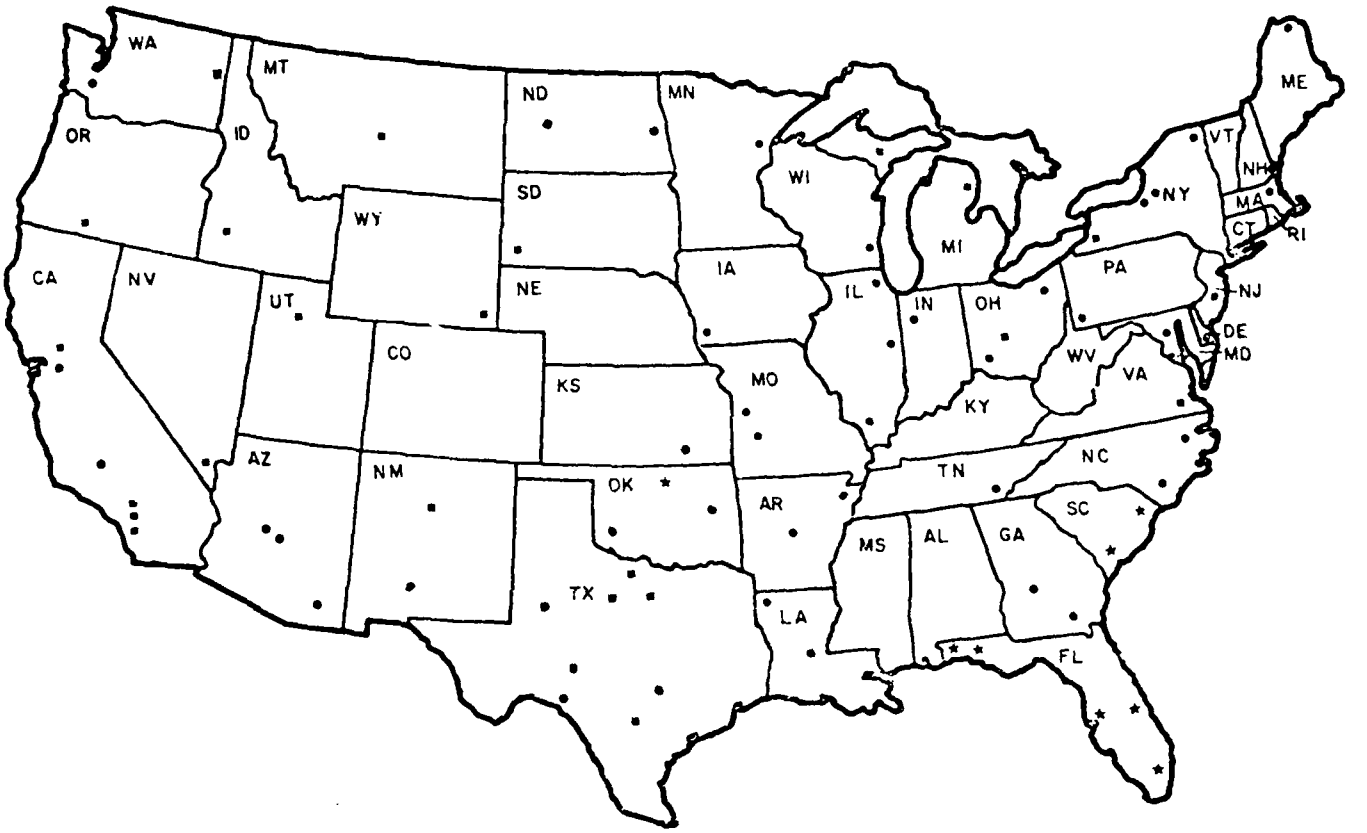


Figure 4.* Map of the United States showing Air Force Base locations and degree of coating/corrosion problems.
* = extensive coating/corrosion problems; • = some coating/corrosion problems; ▪ = no coating/corrosion problems.

1.3 APPROACH

Initially, accelerated laboratory tests were completed to evaluate the initial effectiveness and durability characteristics of selected coating materials for steel structures. Next, outdoor weathering exposure tests were used to measure the long-term coatings performance of selected materials. The test procedures used were, generally, American Society for Testing and Materials (ASTM) performance tests recommended for coatings on steel. The four metal substrates used were cold rolled steel, rusted cold rolled steel, sand blasted cold rolled steel, and galvanized steel. The coating materials tested included high performance types which are commercially available.

The accelerated laboratory tests were designed to screen coating materials for effectiveness and durability. In some respects, these laboratory tests were more severe than real life conditions. However, these tests were useful for the standardized comparison of the performance of different coating materials and were useful for the coordination between accelerated and field test results. The tests provided a basis for the coating materials to be used as part of the development of a model coating guide specification.

The development of a model specification was a major thrust of this project. The model specification developed provided for quality assurance; guidance on inspection and application techniques, including testing equipment; and specific contractor guidance on surface preparation, applications and job site performance standards.

The final phase of this project developed a comprehensive paint inspector's guide for assuring contractor performance to the specification.

SECTION II

EXPERIMENTAL

2.1 COATING SELECTION

2.1.1 Metal Substrates

Four kinds of steel substrates representing types commonly used in the U.S. were chosen for this study. The descriptions of the substrates are as follows:

1. Clean Q-Panel type R, 0.032-inch-thick (0.8mm) cold rolled steel, matte finished.

2. Rusted Q-Panels, same type as above. The panels were solvent cleaned and backcoated with an oil alkyd paint. The panels were then exposed outdoors in a horizontal position for four weeks at the NBS exposure station at Gaithersburg, Maryland. The rusted panels were abrasive blast cleaned by a commercial firm corresponding to an Sa2 appearance of SSPC-Vis 1, i.e., slight rust residue in the pitted surface. The panels were stored over a dessicant until used.

3. Clean ImCO stock, 0.064-inch-thick (1.6mm) cold rolled steel, white metal abrasive blast cleaned.

4. Clean galvanized steel stock, hot dipped, 16 gauge (0.0635 inch [0.0635 inch (1.613mm)].

All test panels were nominal 4-inch by 8-inch (102 by 203mm in size. All panels were backcoated with oil alkyd paint.

The steel and galvanized steel panels used in this study were selected because they represented types commonly used for laboratory and field tests. However, it is recognized that the steel panels were derived from cold rolled steel and hot rolled steel specimens were not included. The Q-panels that were abrasive blasted were selected in order to simulate the effect of a commercially blasted steel which would be more commonly encountered in the field than a white metal blasted steel.

2.1.2 Coating Materials and Sample Preparation

The coating materials used in this study were commercially available materials considered suitable for use on high value steel structures. Manufacturers' instructions on coating thickness and preparation were used for each system, and the components of each system were from one manufacturer. The coatings were thoroughly mixed using a mechanical paint shaker before use. An adjustable

drawdown blade was used to apply the coatings to the desired uniform thickness. The metal panels were solvent cleaned before application of coatings. Since there was some warpage in the panels, an industrial grinding machine with a planar circular table top containing an electromagnet was used to flatten all the panels before coatings application. The primer coats were generally cured for one week, and after application of topcoat, the panels were cured for three weeks at 23°C and 50-percent relative humidity. All panels were backcoated with oil alkyd paint and the code markings applied.

In order to provide the coated panels with incipient failures before exposure, the coating system on each panel was scribed through to the metal substrate and also impacted on the lower half and approximately (20mm) from the outer edges. The panels were scribed with an X with each arm of the X about (20mm) on the lower half of the panels. A variable impact tester was used to apply an impact force of 6 inch-pounds (0.68 Nm) on substrates 1 and 2, a force of 12 inch-pounds (1.35 Nm) on substrates 3 and 4.

Ten specialized coating systems were tested in this study. Each system was identified with a code letter and is described fully in Table 1. These specialized coating systems were selected on their high probability of success in protecting high value steel structures. In fact, the vinyl coatings (e.g., VR-3, SSPC Paint No. 9) used either as a complete system or used over an inorganic zinc primer were not included in this study because of their continued successful use by the military facilities (see also Reference 3 and AFM 85-3). After consultation with manufacturer's representatives, it was decided to compare the performance of a one-package inorganic zinc primer with the more customarily used two-package inorganic zinc primer. Also, a solvent-thinned modified acrylic topcoat was included as it offered possibilities of superior performance along with cost savings. System G, a conventional alkyd paint system, was included as a control for these performance tests.

2.2 TESTING TECHNIQUES

The coating systems selected were tested both in the laboratory and in the field. Six specific tests were used to evaluate the effectiveness and durability of the selected coating materials.

2.2.1 Resistance to Humidity

The purpose of this test was to determine whether the coating systems protected the steel substrates when they were exposed to continuous high humidity and condensation.

The exposure procedure used was that described in ASTM D 2247, "Standard Method of Testing Coated Metal Specimens at 100 Percent Relative Humidity," using a continuous condensation cycle and a

TABLE 1. COATINGS SYSTEMS TESTED

System	Primer	Color	Dry Film Thickness, mils***	Topcoat	Color	Dry Film Thickness, mils***	Total Dry Film Thickness Found, mils***
A*	1 - package inorganic zinc	red gray	2.5	solvent thinned modified acrylic	gray	2.5	5.1 - 5.5
B*	2 - package inorganic zinc	green	2.5	solvent thinned modified acrylic	gray	2.5	5.4 - 5.9
C	polyamide epoxy	red	2.0	silicone alkyd	white	1.5	3.6 - 4.0
D	zinc chromate epoxy	red	1.5 - 2.0	urethane	gray	1.5 - 2.0	2.8 - 4.4
E	3 - package zinc epoxy	gray	4	chlorinated rubber	gray	4	8.0
F	3 - package zinc epoxy	gray	4	high build vinyl	gray	2.5 - 3.5	7.3
G	alkyd, chlorinated rubber	red	1.5	alkyd	gray	3	4.0 - 5.2
H	polyamide epoxy	red	2	solvent thinned modified acrylic	gray	2.5	4.5 - 5.1
I**	zinc rich epoxy	gray	4	urethane	gray	1	5.2 - 5.5
K	2 - package inorganic zinc	green	2.5	-	-	-	3.1 - 3.5

* A thinned mist coat application of the topcoat was applied to avoid bubbling

** A wash primer, 0.3 mil, applied to the surface before primer application

*** 1 mil = 25.4 μm.

38 ± 2°C air temperature. Duplicate samples were prepared for each system. Samples were removed periodically, examined for surface continuity and defects, and color change. For examination of panels for resistance to humidity and subsequent examinations, surface continuity was determined using an Elcometer 9V pin hole detector. Rusting, scribe failure, and blistering were determined using standard methods in ASTM D 610, D 1654, and D 714, respectively. Color differences were measured by the method described in ASTM D 2244 using a Gardner Tristimulus Colorimeter XL-23.

2.2.2 Resistance to Accelerated Weathering

The accelerated weathering test was intended to simulate natural weathering conditions. It was performed to determine if the effectiveness of the coating systems was altered by exposure to ultraviolet light.

The method used was Method A of ASTM G 27, "Standard Recommended Practice for Operating Xenon-Arc Type Apparatus for Light Exposure of Nonmetallic Materials". An Atlas Weather-Ometer with a 6500 watt water-cooled xenon lamp and borosilicate glass inner and outer filters was used. Radiation was monitored at 340 m, and the radiation output was kept constant at 0.53 watts/M^2. The black panel temperature was kept at 60°/C and 50-percent relative humidity. Operation of the lamp was continuous, and the samples were sprayed for 18 minutes during every 120-minute cycle. Duplicate samples were prepared for each system. Samples were removed periodically and examined for surface continuity, defects, and color change.

2.2.3 Resistance to Salt Spray

The salt spray test is intended to simulate a marine environment. Exposure of the panels at a 15 degree angle in a 5-percent sodium chloride environment maintained at 35°C is a severe test of salt spray resistance.

The test procedure used was ASTM B 17, "Standard Method for Salt Spray (Fog) Testing". Two samples of all coating systems and the four types of steel substrate were exposed to 1200 hours of continuous salt spray.

2.2.4 Resistance to Sulfurous Acid Fog

The effectiveness of the coatings in protecting steel from attack from acidic air pollution was evaluated by exposing test speciments to a sulfurous acid fog. The exposure test utilized a lead-lined chamber (Kesternich Cabinet) and the test procedure was that described in the German Industry Standard DIN 50 018, "Testing of Materials, Structural Components and Equipment; Method of test in Damp Heat Alternating Atmosphere Containing Sulfur Dioxide (Cabinet according to Kesternich)".

For each test cycle, two liters of distilled water were placed in the bottom of the test cabinet, and then two liters of sulfur dioxide were introduced. The heating elements in the bottom of the cabinet were then turned on. Within 90 minutes, the temperature in the lower part of the cabinet reached 35°C, resulting in a fog of sulfurous acid. After 8 hours, heating was stopped and the cabinet cooled overnight (16 hours) with the door ajar. The water remaining in the cabinet was drained and replaced with fresh distilled water before starting a new cycle. The concentration of sulfur dioxide in the chamber during the test period was calculated to be 15,000 ppm.

The test specimens were hung vertically with wax-coated hooks, the bottoms of the specimens being about 12 cm from the chamber floor. The backs and edges of all specimens were coated with carnauba wax. Samples were exposed for 30 test cycles. The samples were removed from the chamber, washed with tap water, then with distilled water, and dried before inspection.

2.2.5 Outdoor Weathering Exposure

The purpose of the outdoor exposures for the coating systems was to determine their performance in a natural environment. Three National Bureau of Standards (NBS) exposure stations were used. The stations with their climate types and environments were as follow:

- Fort Holabird, Maryland, "Caf" (see Fig 1), located in an industrial zone of Baltimore.
- Coast Guard Receiving Station, Cape May, New Jersey, "Caf", located 80 feet from the ocean with the samples exposed to salt water spray.
- NBS, Gaithersburg, Maryland, "Caf", rural location.

Although all stations are in the same Climate Type, the Cape May and Fort Holabird stations have characteristically corrosive environments (e.g., salt water and industrial pollution) in contrast to the rural location of the Gaithersburg station.

For exposures, the samples in triplicate were mounted on aluminum racks, facing south at 45°. Exposure times were 6 months and 12 months. A third set of samples remains for indefinite exposure.

2.2.6 Field Test, Andrews AFB

Once laboratory and outdoor weathering tests results were evaluated, a candidate coating system was selected. This coating system was to be field tested on a high value steel structure at Andrews AFB, Maryland. Further, the field test was planned to evaluate the effectiveness of an interim guide specification (Reference 2).

Unfortunately, due to U.S. Air Force procurement problems, this phase of the project could not be completed.

SECTION III

FINDINGS

3.1 LABORATORY AND FIELD TESTS

3.1.1 Testing Techniques

The prime consideration during both the laboratory and outdoor weathering tests was the evaluation of the coating materials to mitigate rusting, blistering, peeling, and other deterioration of the metal testing surfaces.

Accelerated exposure tests, i.e., resistance to humidity, acclerated weathering, salt spray and sulfurous acid, were performed to determine the most effective coating systems. The results of the accelerated exposure tests are listed in Table 2.

Outdoor exposure tests were also used to determine which coating systems were most effective. The results of the outdoor exposure tests are listed in Table 3.

3.1.1.1 Resistance to Humidity. Surface continuity of the coatings exposed in the humidity cabinet was measured at 2, 4, 6 and 8 weeks using a 9V pinhole detector. Coating system D, the zinc chromate epoxy urethane, over substrate 2 developed holidays after 4 weeks exposure and coating system F, the three-package zinc epoxy, high build vinyl, over substrates 1, 2 and 3 developed holidays at the blister areas after 6 week's exposure. None of the systems exhibited rusting after 8 week's although white rust developed at the scribe mark for systems H, polyamide epoxy, acrylic, and I, zinc-rich epoxy, urthane, which are coating on galvanized steel. Some small blistering developed on all panels except K, 2-package inorganic zinc, but systems C, polyamide epoxy, silicone alkyd, and G, alkyd, chlorinated rubber, alkyd, developed larger blisters on all substrates. Color difference measurements on the panels after 8 weeks exposure indicated small color differences for all systems except system I, zinc rick epoxy, urethane, over galvanized zinc and system K, which was an inorganic zinc coating. The larger color differences were probably due to the hydrolysis of the zinc. The three steel substrates did not appear to have any significant influence on rusting, blistering, or color change after 8 weeks exposure. Delamination of the topcoat of systems A and B was noted in the area which had been indented. Since topcoating problems over inorganic zinc primers are very well known, these delaminations were not entirely unexpected.

3.1.1.2 Resistance to Accelerated Weathering

Samples exposed in the Weather-Ometer were periodically examined at 500, 1000, and finally at 1500 hours. In this test, the only

(The reverse of this page is blank)

System	Panel	Color Difference, ΔE, ASTM D 2244				Blistering ASTM D 714			
		Salt Spray 1217 hours	Kesternich Box 30 cycle	WACO 8 weeks	Xenox Arc 1534 hours	Salt Spray 1217 hours	Kesternich Box 30 cycle	WACO 8 weeks	X 15
A	1. Q Panel	0.60	2.27	1.11	1.19	8M	8M	8MD	
	2. Rusted Q Panel	0.47	2.09	0.93	1.30	8F	8M	8MD	
	3. IMCO	1.11	1.06	2.99	1.71	8F	8M	8MD	
B	1. Q Panel	0.84	1.58	3.10	1.25	8F	8F	8F	
	2. Rusted Q Panel	0.32	3.69	3.13	1.60	8F	NC	8F	
	3. IMCO	0.02	4.47	2.59	1.38	8F	8F	8F	
C	1. Q Panel	0.23	0.25	1.06	0.87	8F	#4MD	4M	
	2. Rusted Q Panel	1.84	2.13	1.00	0.86	6D,R3	#4MD,R3	4M	
	3. IMCO	0.35	0.58	0.91	0.97	8M	#4MD,R3	4M	
D	1. Q Panel	0.25	2.07	0.47	0.77	NC	#8F	#8MD	
	2. Rusted Q Panel	0.23	1.11	0.43	0.71	6MD,R3	#8MD	#6D	
	3. IMCO	0.79	0.60	0.52	0.47	8F	#8M,R1	#4MD	
E	1. Q Panel	0.23	0.10	1.44	0.67	8M	8M	8M	
	2. Rusted Q Panel	1.61	2.93	4.14	0.77	8M	8M	8F	
	3. IMCO	0.79	0.34	3.18	0.66	8M	8M	8F	
F	1. Q Panel	0.29	0.90	0.22	1.76	8F	8F	2M	
	2. Rusted Q Panel	0.39	1.09	0.31	1.30	NC	8F	8F	
	3. IMCO	0.47	0.65	0.18	1.89	8F	8M	8F	
G	1. Q Panel	0.18	0.30	0.29	5.76	8M	8M	4M	
	2. Rusted Q Panel	-	-	0.71	8.30	-	-	4MD	
	3. IMCO	0.28	0.66	0.29	8.34	8F	8MD	4MD	
H	4. Gal. Steel	0.32	0.30	7.39	1.33	8F	8F	8M	
I	4. Gal. Steel	0.32	0.52	0.18	2.17	8F	8F	6M	
K	1. Q Panel	14.45	18.56	12.33	3.78	8F,R1	R2,PP	NC	
	2. Rusted Q Panel	19.70	17.68	8.21	5.88	NC	R2,PP	NC	
	3. IMCO	16.68	33.45	13.67	3.32	NC	R2	NC	

No Blistering K System

PP = peeli

Blistering Code

		Character
8F	#8	Few
8M	#8	Medium
8MD	#8	Medium Dense
6MD	#6	Medium Dense
6D	#6	Dense
4M	#4	Medium
4MD	#4	Medium Dense
2M	#2	Medium
NC		No change

Scribe Code

10 = Rating of Hole Dia. (0)
9 = Rating of Hole Dia. (1/64)
8 = Rating of Hole Dia. (1/32)
7 = Rating of Hole Dia. (1/16)
4 = Rating of Hole Dia. (1/4)
3 = Rating of Hole Dia. (3/8)
1 = Rating of Hole Dia. (1" or more)

Indent Code

NC = No change
D = Delaminted

TABLE 2. ACCELERATED TEST RESULTS

14		Scribe Failure ASTM D 1654				Identation			
ACO weeks	Xenox Arc 1534 hours	Salt Spray 1217 hours	Kesternich Box 30 cycle	WACO 8 weeks	Xenox Arc 1534 hours	Salt Spray 1217 hours	Kesternich Box 30 cycle	WACO 8 weeks	Xenox Arc 1534 hours
8MD	8M	9	8	10	10	NC	NC	D	D
8MD	8M	9	8	10	10	NC	NC	D	NC
8MD	NC	9	9	10	10	NC	NC	D	D
8F	NC	9	9	9	10	NC	D	D	D
8F	NC	9	8	9	9	NC	D	D	D
8F	NC	9	9	9	10	D	D	D	D
4M	8F	9	9	8	10	D	NC	D	NC
4M	8F	9	8	10	10	NC	NC	NC	NC
4M	8F	9	7	10	10	NC	NC	NC	NC
#8MD	8F	9	9	10	10	NC	NC	NC	NC
#6D	8F	8	8	9	10	NC	NC	NC	NC
#4MD	8F	7	9	9	10	NC	NC	NC	NC
8M	8F	9	9	9	10	NC	D	NC	NC
8F	8F	10	10	10	10	NC	NC	NC	NC
8F	8F	10	10	10	10	NC	NC	NC	NC
2M	8F	9	9	9	7	NC	NC	NC	NC
8F	8F	10	10	10	10	NC	NC	NC	NC
8F	8F	10	10	10	10	NC	NC	NC	NC
4M	NC	9	9	7	9	D	NC	NC	NC
4MD	NC	-	-	8	10	-	-	NC	NC
4MD	NC	9	9	-	10	D	NC	NC	NC
8M	NC	9	10	1	4	D	NC	NC	NC
6M	NC	9	10	3	0	D	D	NC	NC
NC	NC	10	*	10	10	NC	*	NC	NC
NC	NC	10	*	10	10	NC	*	NC	NC
NC	8F	10	*	10	10	NC	*	NC	NC
			* No Scribe				* No Indent		

PP = peeling paint

Code	Rusting ASTM D 610-68
change	R1 Typical Rust Grade #9 (0.03%)
minted	R2 Typical Rust Grade #8 (0.1%)
	R3 Typical Rust Grade #6 (1.0%)
	R4 Typical Rust Grade #4 (10.0%)

System	Panel	ΔE Color Difference (Outdoor) NBS 6 mos	NBS 1 yr	Ft. Holabird 6 mos	Ft. Holabird 1 yr	Cape May 6 mos	Cape May 1 yr	Blistering ASTM NBS 6 mos	NBS 1 yr	Ft. Hola 6 mos	Ft. Hola 1
A	1. Q Panel	0.68	1.92	1.10	0.33	1.58	2.50	#8M	NC	8M	
	2. Rusted Q Panel	0.90	2.11	1.02	0.20	1.66	4.85	#8F	NC	8M	
	3. IMCO	1.46	1.44	1.69	0.59	2.66	2.68	#8F	NC	NC	
	4. Gal. Steel										
B	1. Q Panel	0.44	0.23	1.30	0.37	2.87	3.11	NC	NC	8F	
	2. Rusted Q Panel	0.23	0.19	1.71	0.28	2.97	1.96	NC	NC	NC	
	3. IMCO	0.68	0.23	1.78	-	2.59	2.82	8F	NC	NC	
	4. Gal Steel										
C	1. Q Panel	1.27	1.47	0.98	-	1.05	1.69	#6M	#6F	8F	
	2. Rusted Q Panel	1.25	1.32	0.66	0.43	0.81	2.18	#6M	#6F	8F	
	3. IMCO	1.34	1.47	1.15	-	0.97	2.09	#6F	#6F	8F	
	4. Gal. Steel										
D	1. Q Panel	1.32	1.01	0.80	0.63	0.31	1.45	#8F	NC	8F	
	2. Rusted Q Panel	1.26	0.92	0.94	0.26	0.33	1.71	#8F	#8F	8F	
	3. IMCO	1.12	1.16	0.85	0.52	0.35	1.38	#8F	#8F	8F	
	4. Gal. Steel										
E	1. Q Panel	0.82	1.35	1.14	0.88	0.51	1.75	NC	NC	8F	
	2. Rusted Panel	1.28	1.51	0.94	0.26	0.75	1.92	NC	NC	8F	
	3. IMCO	1.22	1.06	1.27	0.58	0.74	2.01	NC	#8F	8F	
	4. Gal. Steel										
F	1. Q Panel	1.12	0.42	0.43	0.72	0.81	4.21	NC	#8F	NC	
	2. Rusted Panel	1.35	0.46	0.29	0.66	0.71	4.44	NC	#8F	NC	
	3. IMCO	1.30	0.71	0.37	-	0.48	4.40	NC	NC	NC	
	4. Gal. Steel										
G	1. Q Panel	0.43	7.13	0.69	1.46	1.40	3.33	#8F	NC	NC	
	2. Rusted Panel	0.43	7.05	0.64	1.68	2.11	3.30	#8F	NC	NC	
	3. IMCO	0.31	7.17	0.49	1.58	2.19	2.90	#8F	NC	8M	
	4. Gal. Steel										
H	4. Gal. Steel	0.86	0.42	0.72	0.34	2.26	3.30	NC	NC	NC	
I	4. Gal. Steel	0.39	-	0.51	1.04	2.07	4.19	NC	NC	8M	
K	1. Q Panel	9.42	8.35	5.78	6.92	7.93	6.59	NC	NC	NC	
	2. Rusted Q Panel	8.80	8.05	5.43	6.75	7.51	9.16	NC	NC	NC	
	3. IMCO	8.57	6.87	4.85	5.71	5.43	7.4	NC	NC	NC	

Blistering Code ASTM D 714

Size		Character
8F	#8	Few
8M	#8	Medium
6F	#6	Few
6M	#6	Medium
NC	No change	

Scribe Code ASTM D 1654

10	Rating of Hole Dia.	(0")
9	Rating of Hole Dia.	(1/64")
8	Rating of Hole Dia.	(1/32")
7	Rating of Hole Dia.	(1/16")
6	Rating of Hole Dia.	(1/8")
5	Rating of Hole Dia.	(3/16")
4	Rating of Hole Dia.	(1/4")
3	Rating of Hole Dia.	(3/8")
2	Rating of Hole Dia.	(1/2")

Index
D - D
NC - No

TABLE 3. OUTDOOR WEATHERING TEST RESULTS

tering ASTM D 714				Scribe Failure ASTM D 1654						Indentation					
Ft. Holabird		Cape May		NBS		Ft. Holabird		Cape May		NBS		Ft. Holabird		Cape May	
6 mos	1 yr	6 mos	1 yr	6 mos	1 yr	6 mos	1 yr	6 mos	1 yr	6 mos	1 yr	6 mos	1 yr	6 mos	1 yr
8M	8F	8M	8M	7	5	7	6	0	4	D,R1	D	D	D	D	D,R4
8M	8F	8M	8M	6	7	10	7	7	10	D	D	D	D	D	D
NC	8F	NC	8M	7	9	10	7	10	7	D	D	D	D	D	D
8F	NC	NC	NC	6	8	7	5	3	5	D,R4	D,R1	D	D,R1	D,R4	D,R2
NC	NC	NC	NC	8	8	8	8	9	8	D	D	D	D,R1	D,R1	D,R2
NC	NC	NC	NC	7	6	8	-	6	8	D	D	D	-	D,R2	D
8F	-	8F		5	1	10	-	0	10	D,R1	D	NC	-	NC	D
8F	-	8F	8F	10	10	10	-	9	9	NC	NC	NC	-	NC	D
8F	-	8M	NC	10	10	10	-	9	10	NC	D	NC	-	NC	NC
8F	8F	8F	8F	8	10	10	5	5	10	NC	NC	NC	NC	NC	NC
8F	8F	8F	8F	10	10	10	7	8	9	NC	NC	NC	NC	NC	NC
8F	-	8F	8F	10	10	10	10	9	9	NC	NC	NC	-	NC	NC
8F	NC	8F	NC	4	2	10	3	8	10	NC	NC	NC	NC	NC	NC
8F	-	8F	NC	10	10	10	10	10	9	NC	NC	NC	D,R4	NC	NC
8F	NC	8F	NC	10	10	10	10	8	10	NC	NC	NC	NC	NC	NC
NC	NC	NC	NC	10	10	10	10	10	10	NC	NC	NC	NC	NC	NC
NC	NC	NC	NC	10	10	10	10	10	10	NC	NC	NC	NC	NC	NC
NC	-	NC	NC	10	10	10	-	10	10	NC	NC	NC	-	NC	NC
NC	NC	NC	NC	8	8	8	4	7	7	NC	NC	NC	D	D,R1	NC
NC	NC	NC	NC	9	8	9	8	8	8	NC	NC	NC	NC	D,R1	D,R1
8M	NC	NC	NC	9	8	10	8	8	9	D	NC	NC	NC	NC	NC
NC	NC	NC	NC	3	2	10	10	3	3	NC	D,R1	NC	NC	D,R1	D,R1
8M	8F	NC	8F	7	3	10	10	6	0	NC	NC	NC	NC	D	D
NC	NC	NC	NC	10	10	10	10	10	10	NC	NC	NC	NC	NC	NC
NC	NC	NC	NC	10	10	10	10	10	10	NC	NC	NC	NC	NC	NC
NC	NC	NC	NC	10	10	10	10	10	10	NC	NC	NC	NC	NC	NC

Indent Code
D - Delaminted
NC - No change

Rusting ASTM D 610-68
R1 Typical Rust Grade #9 (0.3%)
R2 Typical Rust Grade #8 (0.1%)
R3 Typical Rust Grade #6 (1.0%)
R4 Typical Rust Grade #4 (10.0%)

(The reverse of this page is blank.)

significant degradation observed was the noticeable color change of system G containing an alkyd topcoat and the delamination between primer and topcoat of systems A and B in the indentation area. No holidays were detected for any of the systems. Considering the length of exposure and laboratory expenditures involved, the xenon arc exposures do not appear to accelerate degradation to the same degree as the other methods.

3.1.1.3 Resistance to Salt Spray

Samples were exposed to salt spray for 1217 hours. Interestingly, moderate blistering and rusting developed with systems C and D which were coated on sandblasted rusty Q panels. Otherwise, blistering was limited, and there was little rusting in the scribe areas. Delamination in the indentation area occurred with systems H and I both over galvanized steel and with the alkyd system G. Little color differences were noted except for system K which was probably due to the hydrolysis of the inorganic zinc. Considering the length of exposure and the severity of the test, all coating systems performed well.

3.1.1.4 Resistance to Sulfurous Acid Fog

Samples were exposed to 30 cycles in the Kesternich box. System C developed moderate rusting and blistering but no delamination in the indentation area. System K developed rusting, and there seemed to be peeling, i.e., inorganic zinc. Overall, there were no scribe failures. However, systems B and I evidenced delamination in the identation area. Color differences were noticeable for systems B and K where the inorganic zinc may have hydrolyzed.

3.1.1.5 Outdoor Weathering Exposure

All systems on all substrates after exposures at the three exposure sites developed only minor blistering. Scribe failures appeared to be directly related to substrates 1 and 4 which are the Q panels and galvanized steel panels. Apparently, the coating systems adhered better to the abrasive blast cleaned substrates. Interestingly, the samples exposed at the NBS exposure station had nearly the degree of rusting at the scribe marks as those exposed at Cape May. Delamination at the indentation area occurred with Systems A, B, C, G, H, and I with rusting in the area particularly with the Q panel substrates. Color changes of the coating systems appeared to be greatest from Cape May exposures and least from the NBS-exposed samples.

3.1.1.6 Field Test, Andrews AFB

Buildings 1170 and 1171 had been chosen as the field test site. One of the buildings was used for water treatment operation, and the other was used as an office building. The buildings were clad with vertical galvanized steel siding which had been painted.

Initially, it was felt that the overall appearance of the existing paint was not severe. However, upon closer inspection, heavy chalking was found on both buildings. Furthermore, using an Elcometer adhesion tester, only 10 to 25 psi were required to break the paint bond to the substrate.

3.2 MODEL COATINGS GUIDE SPECIFICATION

A major thrust of this project was to develop a comprehensive model guide specification that would assure adequate contractor performance when specifying high quality coating materials on high value steel structures. The high value steel structures to be covered by this specification should include steel buildings, communication towers, potable water towers, and fuel storage tanks where the area to be painted is greater than 50,000 sq ft or the contract costs would be expected to exceed $50,000. The model specification developed in Appendix A is an extension of SAC Regulation 85-5, Protective Coatings. The extensions of the existing SAC Specification that makes this model specification truly innovative are:

- A prebid conference is required.
- A three-year guarantee of workmanship is required.
- Paint testing is required.
- The contractor is required to provide inspection equipment.
- Surface preparation and paint application panels shall be used to measure quality assurance.
- An inspection record is required, and it shall contain a photographic record of surface preparation and paint application test panels.
- The requirement that the exposed ferrous substrates be primed no longer than 8 hours after cleaning and in no circumstances that the exposed surfaces be left unprimed overnight.
- The complete coating system must be furnished by one manufacturer.
- Dry film thickness must not exceed a manufacturer's recommended limits.

The intention of the prebid conference is to alert prospective bidders that the level of government inspection, both of materials and workmanship, will be closely monitored. Failure to comply with any phase of the material application could result in the contractor reworking and reapplying the material. Upon completion of the contract, the contractor will furnish a written unconditional

guarantee. Additionally, the coatings manufacturer will provide a written certification stating that the surface preparation and coating installation meet all standards of quality and workmanship. Paint testing will be conducted at government laboratories, funded through the contract. The contractor is responsible for paying all paint testing costs, and supplying all inspection equipment. After the contract is complete, all inspection equipment will become the property of the U.S. Government.

Another significant expansion incorporated into the model guide specification deals with the role of the painting inspection. The inspector is responsible for the calibration of all test instruments, and all measurments of film thickness will be made in the presence of the inspector, the contractor, and the contracting officer. The inspector is also responsible for developing a comprehensive inspection record, which will include photographs of the quality of contractor workmanship. This photographic record is invaluable in settling claims between the U.S. Government, the contractor, and the coatings manufacturers.

To summarize the discussion on the model coatings guide specification, an interim specification was revised to incorporate a strong quality assurance provision for the contractor's capabilities. Additionally, the model specification clearly makes the contracting officer responsible for approval of instrument calibration. The model guide specification is included as Appendix A.

3.3 THE PAINT INSPECTOR'S GUIDE

The key to the successful application or use of the model guide specification is inspection. Inspection may be divided into two important categories: The first, problem identification, definition and assessment; and second, quality assurance to see that the specification requirements are fulfilled. The first inspection category of problem identification, definition and assessment answers the following questions:

- In what condition is the steel surface as it exists now?
- What is the reason or reasons that the coating is failing?
- What decision(s) should be made to remedy the problem?
- What technical instructions are needed?

The second inspection category relates to the quality assurance provisions of the model coatings guide specification and answers the following questions:

- Is the quality of the coating materials used adequate?
- Has the surface been prepared sufficiently to ensure good coating preformance?

- Is the quality of coating application adequate to ensure good coatings performance?
- Has the completed job been appraised properly?

It should be noted that essentially the same inspection tools would be used for both problem identification and quality assurance. Since paint inspectors have been utilized primarily for quality assurance inspections during the painting process, which includes surface preparation, paint application and final approval, it is logical for the Base Civil Engineer to utilize the inspector's expertise for the problem identification phase as well. If the problems connected with the existing steel surface or the reasons that the present coating is failing are not addressed, no matter how well the inspection procedures are carried out for the quality assurance provisions of the model coatings guide specification, premature failures are a distinct likelihood. The analogy would be painting over sand. In regard to the utilization of inspection procedures for both problem identification and quality assurance, Dr. Drisko of the Naval Civil Engineering Laboratory (Reference 4) has developed a programmed painting program at the Naval Training Center, San Diego, which will involve both periodic inspection for problem identification and quality assurance inspection during the painting process. Programmed painting inspection is also addressed in Chapter 2 of AFM 85-3.

The following subsections illustrate the inspection phases of problem identification and quality assurance.

3.3.1 Problem Identification

The first phase in painting or repainting steel surfaces is to determine the condition of the surface. For new or previously uncoated steel surfaces, the visual standard (SSPC-VIS1-SIS 05 5900) defines the four rust grades of structural steel; this standard also contains colored photographs presenting surface preparation standards. Shop-primed coated steel would also be expected to have no rusting except for small areas abraded during handling.

However, most of the steel structures that the U.S. Air Force coating inspector deals with ordinarily have been previously coated. The coating layers may be concealing as much rust as is showing on the surface. The surface condition of the previously coated steel substrate may be classified in accordance with ASTM D 610/SSPC-VIS2 for the degree of rusting. The conditions of the coating film with regard to chalking, blistering, flaking, erosion, checking, and cracking may be classified by the corresponding ASTM visual standards. Instrumentation is available for determining the presence of pinholes, adhesions of the coating film to the substrate, and the film thickness, all of which may affect coating performance. Table 4 presents a matrix of inspector's tools useful for problem identification, and Table 5 is a guide to inspection tools.

TABLE 4. MATRIX OF PAINT INSPECTOR'S TOOLS FOR PROBLEM IDENTIFICATION*

Tools

Process	SSPC-Vis 1	SSPC-Vis 2	ASTM D 659	ASTM D 714	ASTM D 772	ASTM D 662	ASTM D 660	ASTM D 661	Low Voltage Holiday Detector	Elcometer Adhesion Tester	Non Destructive Magnetic Thickness Gage/ASTM G 12/ SSPC-PA 2	Tooke Inspection Gage	Micrometer
Degree of rusting	X	X											
Degree of chalking			X										
Degree of blistering				X									
Degree of flaking					X								
Degree of erosion						X							
Degree of checking							X						
Degree of cracking								X					
Holiday or Pinhole detection									X				
Coating Thickness											X	X	X
Adhesion										X			

* Table 5 list the inspection tools, describes their functions and gives their source of supply. Certain commercial equipment has been identified in Tables 4 and 5 in order to adequately test coating systems. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards or the U.S. Air Force, nor does it imply that the equipment identified is necessarily the best equipment available for the purpose.

TABLE 5. GUIDE TO INSPECTION TOOLS FOR PROBLEM IDENTIFICATION

Tool	Description	Source*,**
Standards, i.e., ASTM D610/ SSPC VIS 2, ASTMD 659, ASTM D714, ASTM D662, ASTM D661, ASTM D660	Visual standards for measurement of rusting chalking, blistering, flaking, erosion, checking, cracking.	1979 Annual Book of ASTM Standards, Part 27, American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103
Holiday Detector	Non-destructive instrument for testing non-conductive films, portable, battery operated, low voltage for films <20 mils, noise detects where there are coating defects, voids or moisture permeable areas.	1, 2, 3
Elcometer Adhesion Tester	The instrument measures the tensile strength of adhesion of coating(s) to substrate; aluminum dolly is cemented to surface with quick setting cyanoacylate adhesive (for field inspection), claw of adhesion tester lifted into dolly head and the dolly is pulled off, the breaking poundage is indicated on the scale.	1, 2, 3
Permament magnet inspector thickness gage (e.g., Elcometer, Microtest)	Measures dry film thickness of non-magnetic material on a ferrous base, shim calibrated thickness read directly from scale; procedures for measurement are given in SSPC-PA2 and ASTM G12.	1,2,3

TABLE 5. GUIDE TO INSPECTION TOOLS FOR PROBLEM IDENTIFICATION (CONCLUDED)

Tool	Description	Source*
Optical thickness gage (Tooke)	Measures thickness on all substrates by 50X illuminated microscope, destructive to coating as cutting tips penetrate into substrate, measures thickness of individual coats, intercoat contamination, voids, etc.	1,2,3
Micrometer	Instrument with adjustable opening to measure thickness of loose paint chips	1,2,3

*1 Gardner Laboratory
Box 5728
5521 Landy Lane
Bethesda, Md. 20014

2 Paul N. Gardner Co.
P.O. Box 6633,
Station 9
Fort Lauderdale, FL
33316

3 KTA Instruments
2020 Montour St.
Coraopolis, PA 15108

** See note, Table 4.

TABLE 6. MAINTENANCE PAINTING CLASSIFICATION

Paint Condition	Degree of Rusting ASTM (D 610)	Coating Thickness, Mils (1 mil = 25.4μm)	Holidays	Adhesion PSI	Remedial Action Surface Preparation & Painting Recommended
Paint almost intact, rust <0.1%, chalk rating (ASTM D 659) >8	8-10	<20	<0.1%	>100	Solvent clean (SSPC-SP1) entire surface or use of high pressure water blast (500-1500 psi) to remove any loose material. Apply 1.5-2.0 mils of finish coat of the same generic type over entire area
Paint deteriorated, as evidenced by chalking 6, blistering, checking, cracking, etc., rust <1%	6-8	<20	<1%	>100	Spot clean (SSPC SP3 "Power Tool Cleaning") feather edge and solvent clean (SSPC-SP1 "solvent cleaning") or use high pressure water blast (500-1500 psi with inhibitor) entire surface. Spot prime, spot apply finish coat and then apply 1.5-2.0 mils of finish coat over entire surface

TABLE 6. MAINTENANCE PAINTING CLASSIFICATION (CONCLUDED)

Paint Condition	Degree of Rusting ASTM (D 610)	Coating Thickness, Mils	Holidays	Adhesion PSI	Remedial Action Surface Preparation & Painting Recommended
Paint severely deteriorated, large portion of the surface covered with rust, holidays and non-adherent paint	0-6	>20	>1%	<100	Clean entire surface, i.e., remove all paint with a minimum of SSPC-SP6 "commercial Blast cleaning," but preferably with SSPC-SP10. Apply primer over entire surface within 8 hours of blast cleaning. Apply intermediate / and finish coat over entire surface.

TABLE 7. PAINT SPRAY EQUIPMENT MANUFACTURERS AND TRAINING COURSES OFFERED

Manufacturer	Training Courses
Binks Manufacturing Co. 9205 W. Belmont Ave Franklin Park, IL 60131	Contact John Adams, Director of Training. Courses are given once a month, 5 days/ $50
DeVilbiss 300 Phillips Ave Toledo, OH 43692	Contact Jack Conrad, Manager of Training Courses, 2 1/2 days/$15. Will set up special course at base.
Graco Inc. P.O. Box 1441 Minneapolis, MN 55440	Training school in Cleveland, OH. They will come to a facility, charging $150 for expenses. They have maintenance and use of equipment on standard video tape.
Nordsen Corp 555 Jackson St Amherst, OH 44001	Will provide instruction on site to person using equipment. Contact Mr. R. Cirell.
Ransburg Corp 3939 West 56th St Indianapolis, IN 46254	Contact Jamey L. Whalen. They hold classes on a regular basis on each type of spray equipment. There would be no charge to go to an Air Force base.

The surface condition of the coated substrate should be quantitatively identified and remedial action made in accordance with the following Table 6.

It should be noted that any paint film greater than 20 mils (0.5mm) thick should be completely removed before repainting, regardless of the degree of rusting. Also, any paint surface which has an Elcometer pull off adhesion rating of less than 100 psi should be completely removed.

The paint failure or problem areas, as evidenced by rusting, loss of adhesion, etc., may be due to anyone or a combination of factors which include: (1) quality of the paint; (2) age of the paint(s), e.g., a paint film 20 mils (0.5mm) may indicate that the oldest paint abuting the steel substrate may be 15-20 years old; (3) poor adhesion [100 psi (<0.7 MPascals)]; (4) atmospheric corrosion; (5) application of the paint under adverse weather conditions, e.g., below dew point, temperature <40° or >95°F (<7.2°C or >35°C); or (6) the surface may not have been properly cleaned. Use of the inspection tools listed in Table 4 should help to identify the reason for the problem.

The condition of the paint, as identified in Table 6, should determine what surface preparation and painting requirements are needed. When the old painted surface is not to be removed, spot test to determine whether the new coating, e.g., epoxies, urethanes, etc., which may contain active solvents, will lift the old paint. If lifting occurs, do not apply the coating. Generally, it is safe to apply the same generic coating over the old paint. Guidance on paint compatibilities is given in AFM 85-3.

When the old painted surface requires complete removal, guidance on recommended coating systems are given in AFM 85-3 and in the model guide Specification for Painting of High Value Steel Structures (Appendix A). The specification also contains technical instructions on paint specifications used and inspection requirements.

3.3.2 Quality Assurance

A summary description of inspection is given in paragraph 1.12 of the model coatings guide specification. Also, inspection procedures are discussed in general terms in AFM 85-3. However, it was felt that more detailed inspection procedures were needed for high value steel structures, and a separate paint inspector's guide was prepared and is included as Appendix B. The guide is divided into the following sections: coating materials, surface preparation, coating application, and approval procedures. Each of these sections contains specific checklist items for use by the inspector. Also included are appendices containing a description and source of inspection tools used for each section, a suggested daily project report, a listing of government paint testing laboratories, a

nomograph for estimating paint quantities used, a description of surface preparation methods, and psychometric table. As noted previously, many of the inspection tools used for problem identification are the same as those used for quality assurance.

Guidance for instruction for painters is extensively discussed in Chapter 4 of AFM 85-3 and guidance for paint application is given in Section 3 of the model coatings guide specification. Since most paint application is by spray, the Thomas Register, the Paint Red Book, and Kline's Guide to the Paint Industry were used to obtain listings of spray equipment. The manufacturers were contacted concerning types of equipment available and recommendations for use, instructions for application, and availability of training courses for using the specialized equipment. While most manufacturers recommended hot or cold airless spray for general use, electrostatic spray equipment is available for use on fences, etc., where overspray must be minimized. Since use of the spray equipment requires specialized training for both application techniques and necessary safety precautions, Table 7 lists manufacturer and courses available.

The need for specialized training when using airless spray equipment is emphasized in the recent Naval Civil Engineering Laboratory Techdata Sheet, 79-01, Safety precautions for Use of Airless Spray Equipment, which illustrates in color the damage that can be done and itemizes a list of accident protection steps.

SECTION IV

SUMMARY AND CONCLUSIONS

Ten coating systems used for this study covered a range of commercially available materials considered suitable for use on high value steel structures. These coating systems were applied on four substrates to determine the influence of surface preparation on coatings durability.

A screening process, based upon the accelerated and outdoor exposure test results, was used to evaluate the initial effectiveness and durability of the coating systems and as a basis for inclusion of selected coating systems into the model specification for painting of high value steel structures.

Adhesion problems appeared prominent in this study in several ways. In general, the adhesion of the coating systems was better when applied to abrasive blasted substrates rather than to the matte-finished Q-panels or galvanized steel. Despite the use of a thinned mist coat, there were intercoat adhesion problems between the solvent thinned modified acrylic topcoat and the inorganic zinc primer. Topcoating of inorganic zinc primers is a continuing problem, but the saving grace is that the inorganic zinc primer protects the steel well, even though the color esthetics may not be too pleasing. The impact test results were interesting, because the impact caused incipient failures in many cases and these were not evident initially. In some cases, intercoat adhesion failure occurred while in the extreme cases, as evidenced by rusting, the entire coating system delaminated from the substrate.

Overall, coating system D, zinc chromate epoxy polyamide primer with a polyurethane topcoat and system F, a 3-package zinc epoxy primer with a high-build vinyl topcoat performed well on the steel substrates and system I, a wash primer, a zinc-rich epoxy primer and an urethane topcoat, performed well on galvanized steel.

While the field test at Andrews AFB was not completed because of U.S. Air Force procurement problems, a number of extremely valuable lessons were learned. These lessons were (1) even if the surface appearance of a coating may look satisfactory, a simple adhesion test is needed to determine whether the coating needs to be removed or whether it could be painted over; and (2) strong qualification requirements are needed for the contractor and his painters, especially for the painting of high value steel structures.

A model specification for painting of high value steel structures was prepared based upon an interim specification and evaluating the results of the accelerated and outdoor weathering tests. Guidance was developed for problem identification, i.e., maintenance of steel structures. Finally, a Paint Inspector's Guide was developed for use with the model specification. Since most paint

application is by airless spray where safety precautions are essential and technial training is required, a list of airless spray training courses was provided.

Based upon the study, the following suggestions are made concerning areas of future studies:

- To explore the life cycle cost effectiveness of the coating systems recommended in the model specification versus the more commonly used alkyd systems, e.g., the life cycle cost effectiveness of programmed painting.

- Expanded adhesion test methods for both laboratory and field use are needed. The mechanism of adhesion failure, the influence of coating and substrate types, and the mechanism of the weathering process would all be components of the investigation.

- The spreading influence of air pollution restrictions, e.g., California Air Resources Board (CARB) regulations, should promote the study of solvent-less or water-borne coating systems for the maintenance of high value steel structures.

- The direction of government purchase of commercially available materials, and this would include high performance maintenance coatings for steel, initiated by the DOD directive, "Development and Use of Non-Government Specifications and Standards", implies that alternate means of quality assurance will have to be developed and used rather than federal or military specification requirements.

- To evaluate the effectiveness of the model guide specification, once several contracts are completed. Incorporate the lessons learned from contract efforts into the specification. Rewrite the specification into the acceptable Construction Specifications Institute (CSI) format.

REFERENCES

1. L. H. Bennet, et al., "Economic Effects of Metallic Corrosion in the United States, Part I, NBS Special Publication 511-1, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1978).

2. P. G. Campbell, G. A. Sleater, Protective Coatings for Steel Structures: Part 1 Survey of Air Force Coating Problems and Development of an Interim Guide Specification, NBSIR-79-1773 (June 1979).

3. "Cracking Down on Corrosion", SG-713, Committee of Sheet Steel Producers, American Iron and Steel Institute, 1000 16th Street NW, Washington, D.C. 20036 (1978).

4. Techdata Sheet 79-10, Programmed Painting, Civil Engineering Laboratory Naval Construction Battalion Center, Port Hueneme CA 93043 (December 1979).

(The reverse of this page is blank)

APPENDIX A

MODEL GUIDE SPECIFICATION FOR PAINTING OF HIGH VALUE STEEL STRUCTURES

PREFACE

i. Use this model guide specification in the preparation of contract specifications for coating the interior or exterior of high value steel structures. Do not make it part of the contract merely by reference; copy pertinent portions into the contract documents.

ii. Notes are included in this model for the information of the designer and specification writer. Do not include these notes in the contract specification.

iii. Information in parentheses () is included for clarification or to indicate options required to tailor this model to fit the individual project. Delete provisions not applicable to the project and remove parentheses before typing the contract specification.

iv. This model specification is considered appropriate to the coating/painting of new construction surfaces or the recoating/painting of previously coated surfaces, the important differences being that of preparing the surface to receive the specified coating. The performance requirements of all steps must be fully qualified.

v. A prebid conference is required for high value steel structures where the area to be painted is greater than 50,000 ft^2 or the contract costs are expected to exceed $50,000. The type of structures covered by this specification include communication towers, hangars, potable water towers, fuel storage tanks, etc. At this conference, the specifications will be explained in detail, including the work certification clause and a three-year guarantee of workmanship. In the event the low bidder has not attended the prebid conference, he shall sign a statement that he has read and understood the provisions of the specificiation.

vi. Bidders shall be prepared to provide the following information on specialist qualifications immediately following bid submittal and prior to award to aid in the identification of the firm best qualified to perform the work:

A. Firm's or individual's names, addresses, telephone numbers, and dates organized.

B Firm's painting experience in projects completed in the last five years considered to be of a similar

nature. This experience should list the following: project name, owner's representative to contact, date completed, and total cost. Proof of experience may include photographs, work descriptions, etc.

C. Individual's experience in the past five years of the specialized nature required of this structure relating to scaffolding, surface preparation by abrasive blast cleaning, and paint application by various spray techniques. This experience should list the following: project name, owner's representative to contact, date completed, and total cost. Proof of experience may include photographs, work descriptions, etc.

The term "specialist" as used shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field), which is regularly engaged in and which maintains a regular force of workmen skilled in painting high value steel structures or otherwise performing work required by the contract. Specialist qualifications as required above shall be subject to approval of the contracting officer.

PROTECTIVE COATINGS

SECTION 1

GENERAL

1.1 DESCRIPTION

These specifications and associated drawings provide details and performance requirements for surface preparation, coating materials, and finish application necessary to this protective coatings project. The term "coating," as used, includes (emulsions) (enamels) (paints) (lacquers) (varnishes) (sealants) (fillers) and other coatings whether used as prime, intermediate, finish or single application. The contractor will furnish (all) (as applicable) paint, supervision, labor, equipment, and materials to execute and satisfy the requirements of this contract as hereinafter detailed and described.

The work to be performed under this contract consists of (washing) (repairing) (abrasive blasting) (water blasting) (roto-blasting) (scraping) (solvent cleaning) (steam cleaning) the steel surface where rust or deteriorated paint removal is required and other operations necessary to prepare a surface for protective coating application. The work to be performed under this contract also consists of painting all prepared surfaces. Facilities making up this contract consist of Building _____.

On each painted structure, on the corner of the same wall as the building number and located at the lower edge of the painted surface, the paint system code shall be stenciled. The stencil (approximately 6 in^2) shall contain the following information:

Contractor_____
Paint System (Fed/or Mil Specification(s))
Date of Application: _____
Paint Manufacturer _____

NOTE 1: Structural repairs needing correction prior to paint application are to be identified and included as separate bid items. Technical provisions covering significant repairs are to be included under a separate section of these technical provisions.

NOTE 2: If minor structural repairs cannot be performed in-service prior to painting, identify the scope of repair required as part of the painting technical provisions.

1.2 LOCATION

Contract to be performed at _____ AFB on all (buildings, structures, facility, or piping) as shown on the site plan drawing No. _____.

1.3 TECHNICAL SECTION

The following section of these technical provisions describes work to be performed. The contractor is responsible for determining the appropriate division of work where subcontractors are utilized.

SECTION

1. General

2. Structural Repairs (welding - sheet metal - etc.)

3. Cleaning, Preparation, and Pretreatment of Surfaces.

4. Application

5. Painting Schedule

1.4 SUPERVISION

Competent supervision shall be provided by the contractor at all times when work is in progress. The contractor or his supervisor shall coordinate and schedule contractor effort and insure that work accomplished and materials used are in conformance with technical provisions of this contract. The contractor or his supervisor shall note discrepancies and disparities in technical provisions, drawings, and other instructions and present them to the Contracting Officer in writing for correction and clarification.

1.5 CONTINUED USE OF FACILITIES

(Buildings) (structures) (facilities) (utilities) will continue in use during this contract. Work and work areas shall be scheduled at least 24 hours in advance of anticipated time of accomplishment. Work shall be performed in a manner to create minimum disturbance and inconvenience to occupants. Contractor personnel will be limited to work areas.

1.5.1 Work schedule

Working hours for the contractor will normally be between the hours of _____ AM and _____ PM excluding Saturdays, Sundays, and Federal holidays. If the contractor wishes to work during periods other than above, additional Government inspection forces will be required. The contracting officer must approve each request to work during periods other than normal duty hours. The contractor must notify the contracting officer 24 hours in advance to work during other periods to allow assignment of additional inspection forces.

NOTE 3: If such force is reasonably available, the contracting officer may authorize the contractor to perform

work during periods other than normal duty hours/days; however, if inspectors are required to perform in excess of their normal duty hours/days primarily for the benefit of the contractor, the actual cost of overtime inspection will be charged to the contractor and will be deducted from the final payment of the contract amount.

1.6 CONTRACTOR-FURNISHED OPERATING EQUIPMENT

The contractor shall provide all equipment necessary to accomplish the contract. Power equipment shall be equipped with safety, noise-limiting, and fume control devices and shall be in a safe and efficient operating condition.

1.7 CONTRACTOR-FURNISHED INSPECTION EQUIPMENT

The contractor shall provide all equipment necessary for the inspection of work covered by the contract as specified in 1.12.6. This inspection equipment shall become the property of the Government upon completion of the contract, and the equipment shall be in operating order when accepted by the Government.

1.8 APPLICABLE STANDARDS, PUBLICATIONS, SPECIFICATIONS, AND TECHNICAL DESCRIPTIONS

Unless specifically exempted by this specification and drawings, all work accomplished under this contract shall conform to the most recent standards and codes established by the following publications:

1.8.1 Federal Standards

No. 141 and Change	Methods for inspection, sampling and testing of paint, varnish, lacquer, and related materials.
No. 595, A and Change	Color.

1.8.2 Department of Defense

MIL-STD-101	Color Code for Pipelines and for Compressed Gas Cylinders.
MIL-STD-161	Identification Methods for Bulk Petroleum Products Systems Including Hydrocarbon Missile Fuels.

1.8.3 Others

Steel Structure Painting Council, Manual, Vol. 1 and 2.

1.8.4 Federal Specifications (List applicable specifications)

1.8.5 Military Specifications (List applicable specifications)

NOTE 4: Specify the most up-to-date edition of each specification and only include the specifications for the family of coatings intended.

1.9 MATERIALS

Materials shall conform to the requirements of the specification shown in the paint schedule and the requirements herein. Paints shall be in sealed, unbroken containers that plainly show the designated name, formula or specification number, batch number, Fed Std 595 color, data of manufacture, manuafacturer's instructions, and name of manufacturer. Paints shall be furnished in containers not larger than five-gallon capacity. Materials shall be homogeneous and show no separation that cannot be overcome by stirring, and when mixed, shall permit application by brush, roller, glove, or airless spray methods. Paints stored more than 12 months shall not be used. All materials furnished will be subject to testing. The complete coating system, e.g., primer, intermediate coat, and topcoat(s), will be furnished by one manufacturer. The coating systems must be submitted as a family. When the bid is submitted, the bidder must indicate the manufacturing source.

1.10 SAMPLES AND TESTING

1.10.1 Contractor-furnished paints and painting materials proposed for use shall be stored at the project site or in an area and manner acceptable to the contracting officer or his representative (see paragraph 1.11). Sample containers shall be sealed and labeled.

After paint materials are received or placed in storage, the contracting officer or his representative, in the presence of the contractor, will take a one-quart sample of each batch by random selection of sealed containers. Samples shall be clearly identified by designated name, specification number, intended use, and quantity in gallons involved. The Government shall be responsible for shipping the samples. The contractor (shall) (may) add 5 percent to the contract bid for contracts up to $10,000 to be set aside for paint testing. The contractor (shall) (may) add $300 for each type of primer/paint to the contract bid for contracts over $10,000 to be set aside for paint testing. All testing will be accomplished at a government-operated laboratory. A list of government laboratories is contained in the Directory, U.S. Government Inspection Services and Testing Laboratories, July, 1976, General Services Administration, Federal Supply Services,

Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402. All paint testing will be paid for by the contractor. Where a sample fails to meet specification requirements, the contractor must take all necessary action to reprepare the surfaces painted with material represented by the sample which failed testing and apply an acceptable coating. The expense of retesting will be deducted from the payments due the contractor at the actual cost for each sample tested.

NOTE 5: Testing is required for quantities of paint in excess of 20 gallons or sensitivity or critical aspects of the area in which work is to be performed necessitates testing of coating material of a lesser value. The value of each product to be used under the paint contract will be estimated by the project designer or specification writer. The latter information and items to be tested will not be disclosed to the contractor. For 20 gallons or less, the factors of time, value of material versus cost of testing, and the end use of the material may justify acceptance on the basis of test reports furnished.

NOTE 6: Allow 30 days for testing of paint materials.

1.10.2 Overseas Samples and Confirmation Testing

The contractor shall furnish either of the following for all batches of paint proposed for use.

1.10.2.1 A certified test report showing that batch proposed met all specification requirements.

1.10.2.2 A certified test report showing that a previous batch manufactured using the same formulation as that used in manufacturing the batch proposed met all specification requirements and a report showing test results on the batch proposed for the following properties for which there are requirements in the material specification: Weight per gallon, viscosity, fineness of grind, drying time, color, glass, etc.

1.11 STORAGE FACILITIES

1.11.1 Contractor-furnished material and equipment must not be stored in the work area. The contracting officer or his representative will assign the storage area and will approve the contractor-supplied storage shed.

1.11.2 Storage of Contractor-Furnished Painting Materials.

Paint materials shall be stored at the site in an approved contractor-furnished (building) (storage van) of size to contain all painting materials and be capable of maintaining 50°F (10°C)

temperature, minimum. Windows, if any, shall be permanently secured, and the one door must have two hasps. The contractor and government will each provide a lock and five keys. All painting materials upon receipt shall be placed in the previously described storage facility. This security method insures that painting materials can be stored, sampled, and removed for use only when both contractor and contracting officer or his representative are present.

1.11.3 Contractor shall provide secure safe storage for all items removed from structures during preparation and painting operations. Provisions shall be made to protect all items from loss or damage from weather, vandalism, and other causes. Items shall be labeled and stored immediately after removal from installed locations. Contractor shall note and call the attention of contracting officer or his representatives to all damaged items. All items or building components damaged or lost as a result of contractor operations shall be repaired or replaced at no cost to the government. Removed items shall be reinstalled as part of this contract.

1.11.4 Broken glass, used solvents and other hazardous material resulting from preparation or painting operations shall be removed immediately to a government-identified (on-base) (off-base) disposal area.

NOTE 7: Disposal area and distance to area must be shown on site location drawing.

1.12 INSPECTION

1.12.1 Contractor shall accomplish work in an orderly progression of steps to satisfy the performance requirements of this specification. The following items of work will be considered steps or phases: repair; cleaning; surface preparation such as filling; smoothing; removal of scale or old paint; application of sealer; application of primer; and the separate application of subsequent coats.

1.12.2 Contractor shall anticipate the completion of each step or phase and schedule the inspection of the phase by the contracting officer at least eight hours in advance to preclude possibility of delay.

1.12.3 Contractor shall not initiate or commence on any subsequent step or phase until the previous phase has been approved by the contracting officer.

1.12.4 Any material applied by the contractor to a subsequent phase before receiving contracting officer approval of a prior phase shall be corrected by removing applied material. In addition, the contractor shall perform all work required for earlier phases and secure required approvals at no cost to the government.

1.12.5 Completed areas or items shall be scheduled for final inspection within 72 hours of time of completion. Deficiencies shall be corrected within three workdays following the scheduled final inspection and rescheduled for inspection.

1.12.6 The government may use any or all of the following equipment or comparative standards and samples in field testing and inspecting the work to affirm compliance with the contract requirements. The contractor shall have available the inspection equipment, comparative standards, and all associated instructions for use and calibration. The contracting officer will have the responsibiltiy for final approval of the calibration of the instruments used. The equipment to be furnished consists of (Polaroid® camera), (wet film gages), (dry film gages), (surface thermometers), (wet and dry bulb thermometers or portable psychrometer), (surface profile gages), (holiday detectors), (20 power magnifying lens), and (viscometers).

1.12.7 Random samples will be taken from painter's buckets or from spray nozzle and tested for weight per gallon, viscosity, fineness of grind, hiding, etc. When a sample fails to meet specifications, the material represented by the sample will be removed and replaced at no cost to the government.

1.12.8 Film thickness tests will be taken on a random basis on all surfaces painted. When surfaces tested do not meet film thickness specifications, the wall or 400-square-foot area (37 m^2), whichever is less, shall be repainted at no cost to the government. Damage incurred through destructive testing such as dry film thickness tests shall be repaired or touched up at no cost to the government.

1.12.9 Photographs taken by the Contracting Officer or his representative after surface preparation, during application, and after completion of painting are to be considered part of the inspection record. They are to be signed and dated by the inspector and contractor with a brief description of the picture's contents.

NOTE 8: Be sure to incorporate an adequate scale in the photographs taken. This can easily be done by including a small ruler in the picture frame.

1.13 BIDDER QUALIFICATIONS

Bidders shall be prepared to provide the following information on specialist qualifications immediately following bid submitted and prior to award to aid in the identification of the firm best qualified to perform the work:

a. Firm or individual names, addresses, telephone numbers, and dates organized.

b. Firm's painting experience in projects completed in the last five years considered to be of a similar nature. This experience should list the following: project name, owner's representative to contact, date completed, and total cost. Proof of experience may include photographs, work descriptions, etc.

The term "specialist" as used shall mean individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field), which is regularly engaged in, and which maintains a regular force of workmen skilled in painting high value steel structures or otherwise performing work required by the contract. Specialist qualifications as required above shall be subject to approval of the contracting officer.

1.14 GUARANTEE

The contractor will furnish a written guarantee which will unconditionally guarantee the new coating to be free from any physical defect or deterioration which would affect its functional performance for a period of three years from the date of final acceptance of the contract work. Defects will be repaired or replaced by the contractor to the satisfaction of the contracting officer as often as necessary throughout the period of the original guarantee. During the guarantee, the contractor shall not be held liable under the terms of the guarantee for:

a. Any damage to the coating caused by failure of the painted structure.

b. Any damage to the coating caused by abrasions or abuse from unforeseen causes beyond the control and without fault or negligence of the contractor.

c. Any damage caused by fire, lightning, or act of public enemy.

1.15 WORK CERTIFICATION

Upon completion of the work and prior to final payment of the contract, the contractor and the coatings manufacturer will furnish the contract officer a certification signed by both the manufacturer and the contractor that the surface preparation and coating installation was in no manner deleterious to the performance of the coating. Any cost for the coating manufacturer to supply inspection, certification, etc., will be included in the contract bid.

1.16 PAYMENT

No separate payment will be made for the work covered under this section of the specifications and all costs in connection therewith shall be included in the lump sum contract price for the entire work to be performed under this contract.

SECTION 2

STRUCTURAL REPAIRS

(Section 2 shall be included as applicable)

SECTION 3

CLEANING, PREPARATION, AND PRETREATMENT OF SURFACES

3.1 GENERAL

Painting operations shall not begin until surface has been conditioned or prepared to receive a protective coating by the contractor and then inspected and approved as ready for the coating application.

Surfaces to be painted shall be clean before applying paint or surface treatments. Oil and grease shall be removed with clean cloths and cleaning solvents before mechanical cleaning. Cleaning solvents shall be of low toxicity and shall have a flashpoint in excess 100°F (37.8°C). Solvents, thinners, and mineral spirits will conform to Los Angeles Rule 442 or other applicable NIOSH standards.

Cleaning and painting shall be so programmed that dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces. Drips, runs, and irregularities in the existing of previously applied coating shall be made smooth before application of coating. Plants, shrubs, and vines growing along structural foundations or fastened to buildings will be loosened and laid back until the paint is dry and then refastened. The workmen must protect all plants. Contractor's protective interior and exterior coverings must be removed after each space or area is painted and at the end of each day, if the space is in use.

NOTE 1: See air polution criteria for volatility of solvent.

3.1.1

Items not previously painted or listed as "items not to be painted" shall be removed and placed in secure storage for later replacement in original location or will be protected by masking or drop cloths.

3.1.2

Exposed radiators and heating or cooling units shall be temporarily removed to facilitate painting otherwise inaccessible surfaces.

3.1.3

Screws and other renewable fasteners shall be removed from surface to be painted and holes shall be repaired and made ready for painting.

3.1.4

Removal and reinstallation of building or structural items shall be accomplished by workmen skilled in the crafts involved.

Ferrous surfaces that have not been shop-coated shall be solvent-cleaned to remove oil and grease. Surfaces that contain loose rust, loose mill scale, and other foreign substances shall be mechanically cleaned or sandblasted. After cleaning, one coat of ferrous metal primer shall be applied to ferrous surfaces to receive paint not to exceed 8 hours after the surface preparation operation. In no case shall the unprimed substrate be left uncoated overnight. Contractors will abrade only that area that can be coated in the same work period.

NOTE 2: For ferrous material, select and use completely the appropriate surface preparation or cleaning method recommended by AFM 85-3, AFM 88-15, Steel Structures Painting Manual, or other competent authority.

3.1.5 All dirt, rust, scale, loose rust, loose mill scale, welding flux and slag, oil and grease, and other detrimental matter which may impair adhesion of the coating shall be removed. Welds, weld splatter, burrs, and sharp-edges or protrusions shall be ground smooth. Voids from cracks, crevices, back-to-back angles, etc. must be filled.

3.1.6 All loose, cracked, brittle, nonadherent paint shall be removed in cleaning unless it is otherwise specified. Where the remaining paint is excessively thick, all exposed edges shall be feathered. Spot cleaning shall be conducted in a manner which will minimize damage to sound paint. Rust spots shall be thoroughly cleaned, and the edges of all old paint shall be scraped back to sound material.

3.1.7 When an old painted surface is not to be removed completely, a high pressure water spray, 500 - 1500 psi (3.4 -10.3 MPascals), containing suitable rust inhibitor(s) shall be used to remove loose paint and dirt on the surface. Spot test painted surfaces to determine if coatings containing active solvents (e.g., urethanes and epoxies) will lift the old coating. If lifting occurs, do not apply the coating. The contractor shall request the contracting officer to specify corrective action. However, any rust exposed during the cleaning process shall be removed by abrasive blasting.

3.1.8 The contractor shall have the right to remove all old paint from areas where the amount of damaged or loose paint is excessive.

3.1.9 Paint that curls or lifts after application of the spot or priming paint shall be removed and the area shall be repainted.

3.1.10 A test panel shall be prepared by the contractor to be used as a standard of surface preparation. The test panel shall

be an approximately 4 feet by 4 feet (1.2m by 1.2m) section on the structure to be painted. The degree of surface preparation shall be approved by the contracting officer or his delegated representative before surface preparation is continued. Photographs of the cleaned and approved test panel shall become part of the inspection record and are to be signed and dated by the inspector and contractor with a brief description of the picture's contents.

NOTE 3: There are four degrees of blast cleaning. See Steel Structures Painting Council (SSPC) Manual No. 2 or AFM 85-3, chapter 4, for greater detail.

NOTE 4: For special purpose coatings, surface preparation of structures such as fuel oil tanks, demineralized water tanks (AFM 85-3, chapter 10) use cleaning method outlined in AFM 85-3, chapter 4, or Steel Structures Painting Manual, volume 2.

NOTE 5: Power tool cleaning in accordance with SSPC preparation No. 3 is permitted where abrasive blasting will damage adjacent surfaces or contaminate the adjacent equipment.

3.2 NONFERROUS METALS

(Aluminum) (aluminum alloy) (copper) (galvanzed steel) surfaces shall be free of all corrosion products, loose and foreign material, and shall be solvent cleaned and treated with a vinyl type of wash coat prior to primer and topcoat applications.

3.3 BLAST CLEANING

Painting schedule indicates the SSPC specification number to be used for blast cleaning. The painting schedule will refer to one or more of the following SSPC specification number(s).

SSPC-SP 6 No. 6	Commercial Blast Cleaning
SSPC-SP 10 No. 10	Near-white Blast Cleaning
SSPC-SP 5 No. 5	White Metal Blast Cleaning

In all of these procedures <u>all</u> the old paint is removed.

Compliance with surface preparation specifications Nos. 5 and 6 will be based on the pictorial standards of SSPC-Vis 1. The appearance of the surface after Near-white Blast Cleaning shall correspond with pictorial standards Bsa 2-1/2, Csa 2-1/2, or Dsa 2-1/2 of SSPC-Vis 1. Immediately after cleaning and after the inspection, the specified primer coating shall be applied. The paint schedule will indicate when a pretreatment coating is required on steel. In this case, apply pretreatment before application of primer paint. Shop or field applied prime coated

metal will be protected from corrosion during transit, before and after installation. Treat deteriorated areas immediately upon detection.

3.4 ELEVATED TEMPERATURES

Steel stacks and other surfaces subject to elevated temperatures shall be prepared for painting by use of SSPC-SP-1, Solvent Cleaning, followed by SSPC-SP-6, Commercial Blast Cleaning. The types of coatings used for these surfaces are indicated in the painting scheduled herein and must be applied at the stack temperatures recommended by the manufacturer.

3.5 PETROLEUM STORAGE TANKS

The interior surfaces of ferrous petroleum storage tanks shall be thoroughly cleaned of dirt, oil, or grease prior to white blast cleaning. Oil or grease shall be removed by the methods outlined in SSPC-SP-1, Solvent Cleaning.

3.5.1 Following cleaning, the tank interior surfaces shall be dry sandblasted in accordance with the requirements of SSPC-SP-5, White Metal Blast Cleaning. After blasting, the tank surfaces shall be brushed and blown off with compressed air or cleaned by vacuum before application of the primer coating.

3.5.2 The primer should be applied as soon as possible after the blast cleaning and *in no case* shall the time interval exceed 8 hours. If any visible rusting does occur after blasting regardless of the time interval, the surface shall be reblasted prior to applying the primer. The sandblasting and application of the lining shall not be done when the steel surface temperature is less than 27°F (1°C) above the dew point temperature of the surrounding air. This condition will most likely occur in underground tanks. For such cases, heated air shall be circulated through the tank as required to maintain this 2°F (1°C) temperature differential and thereby prevent condensation of moisture on the tank surface.

3.4 ELEVATED TEMPERATURES

Steel stacks and other surfaces subject to elevated temperatures shall be prepared for painting by use of SSPC-SP-1, Solvent Cleaning, followed by SSPC-SP-6, Commercial Blast Cleaning. The types of coatings used for these surfaces are indicated in the painting scheduled herein and must be applied at the stack temperatures recommended by the manufacturer.

3.5 PETROLEUM STORAGE TANKS

The interior surfaces of ferrous petroleum storage tanks shall be thoroughly cleaned of dirt, oil, or grease prior to white

blast cleaning. Oil or grease shall be removed by the methods outlined in SSPC-SP-1, Solvent Cleaning.

3.5.1 Following cleaning, the tank interior surfaces shall be dry sandblasted in accordance with the requirements of SSPC-SP-5, White Metal Blast Cleaning. After blasting, the tank surfaces shall be brushed and blown off with compressed air or cleaned by vacuum before application of the primer coating.

3.5.2 The primer should be applied as soon as possible after the blast cleaning and in no case shall the time interval exceed 8 hours. If any visible rusting does occur after blasting regardless of the time interval, the surface shall be reblasted prior to applying the primer. The sandblasting and application of the lining shall not be done when the steel surface temperature is less than 2°F (1°C) above the dew point temperature of the surrounding air. This condition will most likely occur in underground tanks. For such cases, heated air shall be circulated through the tank as required to maintain this 2°F (1°C) temperature differential and thereby prevent condensation of moisture on the tank surface.

SECTION 4

APPLICATION

4.1 GENERAL

The finished surfaces shall be free from runs, drops, ridges, waves, laps, brush marks, roller marks, and variations in color, texture, and finish. The coverage shall be complete, and each application shall be so applied as to produce film of uniform thickness. Special attention shall be given to insure that all surfaces including edges, corners, cracks, fissures, crevices, welds, and rivets receive a film thickness equal to that of adjacent painted surfaces. All fissures or openings in previously painted surfaces shall be thoroughly filled and sealed by applied coating. Adjacent areas and installations shall be protected by use of drop cloths or other approved precautionary measures. Lifting or raising of old paint caused by the new application must be immediately called to the attention of the contracting officer or his representative by the contractor. Application of new coating shall cease until the type of corrective action required has been determined and implemented.

4.1.1 Test Panel

A test panel shall be prepared by the contractor to be used as a standard for paint application. The test panel shall be an approximately 4-foot by 4-foot (1.2m by 1.2m) section of the structure to be painted. The same panel area used as a standard for surface preparation may be used as the substrate for paint application. The wet and dry film thickness and film continuity shall be tested as in paragraph 4.6.1. The paint application shall be approved by the Contracting Officer or his delegated representative before the paint application is continued.

Photographs of the approved panel shall become part of the inspection record and are to be signed and dated by the inspector and contractor with a brief description of the picture's contents.

4.2 COATING PROGRESS

Sufficient time shall elapse between successive coats to permit proper drying, as recommended by the paint manufacturer. This period shall be modified as necessary to suit adverse weather conditions.

4.3 STORAGE, MIXING, AND THINNING

4.3.1 General

At time of application, paint shall show no signs of hard settling, excessive skinning, livering, or other deterioration. Paint shall

be thoroughly stirred and kept at a uniform consistency during application. Paints of different manufacturers shall not be mixed together. Where necessary to suit conditions of surface, temperature, weather, and method of application, packaged paint may be thinned immediately before application per manufacturer's instructions but not in excess of one pint of suitable thinner per gallon. Primer paint shall be thinned as necessary to insure wetting and penetrating action.

4.3.2 Vinyl-type wash coating conforming to Military Specification MIL-P-15328 shall be mixed by adding one volume of acid component to four volumes of resin component. The acid component shall be added slowly with constant stirring to the resin component. After mixing, the wash coat shall be used within eight hours. If additional thinning is required to maintain a wet spray, reduction shall be made with butyl alcohol or 99 percent isopropyl alcohol.

4.4 ATMOSPHERIC CONDITIONS

Paints other than water-thinned coatings shall be applied only to surfaces that are completely free of surface moisture as determined by sight or touch. In no case shall paint be applied to surfaces upon which there is visible frost or ice. While painting is being done, the temperature of the surfaces to be painted and of the atmosphere in contact therewith shall be at or above 45°F (7.2°C). The application of the paint shall not be done when the steel surface temperature is less than 2°F (1°C) above the dew point temperature of the surrounding air. A surface temperature thermometer will be used to check surface temperatures. During periods of inclement weather, painting may be continued by enclosing the surfaces with temporary shelters and applying artificial heat, provided the temperature requirements prescribed above are maintained. Unvented combustion-type heaters will not be permitted.

4.5 TIME BETWEEN SURFACE PREPARATION AND PRIME PAINTING
(see also paragraph 3.1.4)

Surfaces that have been cleaned, pretreated, or otherwise prepared for painting shall be given an application of the specified (pretreatment primer) material as soon as practicable after such preparation has been completed, but in no case exceed 8 hours. Where prepared surface has deteriorated, the surface conditioning process will be repeated to restore required surface. All prepared surfaces must be coated prior to the end of the work period when the base substrate was exposed.

4.5.1 Time Between Application of Successive Coats

The time between application of successive coats of paint over the primed substrate shall be not <u>less than or exceed</u> the paint manufacturer's directions.

4.6 APPLICATION METHODS

Paint may be applied by (brushing) (rolling) (air spraying) (airless spraying) (or a combination of these methods). Daubers or sheepskins may be used when no other method is practicable for proper application in places of difficult access.

Irregular surfaces such as rivets, bolts, crevices, welds, corners or edges shall be coated with primer by brush application prior to main primer application. Dripping or flow coating shall be used only when specifically authorized. Special provisions for specific methods of application are given in paragraphs 4.6.2 through 4.6.5.

4.6.1 Thickness and Continuity

Liquid films shall be applied over surfaces to produce a new film lamination of the required dry uniform thickness. Exercise care to insure that all laps blend to produce a uniform appearance and thickness. Each application of coating shall be applied at the coverage rate (square feet per gallon) (m^2/ℓ) necessary to obtain the dry film thickness, as specified in the painting schedule. A wet film thickness gage may be used by the contractor as a guide to indicate whether the coverage rate of paint is sufficient to produce the specified dry film thickness. However, the specified dry film thickness must be obtained. Before use, all wet and dry film thickness gages must be approved for adequacy and calibration by the contracting officer's representative. Adulteration of the paint to obtain wet or specified dry film thickness readings will not be permitted.

NOTE 1: Show paint coverage rates or dry film thicknesses under the specific material paragraph in the Painting Schedule.

4.6.1.1 In the event the required thickness is not achieved as specified, additional paint shall be applied until the required thickness is obtained.

4.6.1.2 Dry or wet film thickness will be gaged or approximated by the government utilizing some or all of the test equipment listed in paragraph 1.12.6.

4.6.1.3 Holiday detectors and magnifying lenses will be used to examine defects such as holidays (pits) and other surface blemishes in the film. Magnifying lenses of 20 power will be used to inspect for mildew or other foreign substances in the dry film. A drawdown applicator for comparison may be used to measure variations in color, gloss, and opacity of the film. Viscometers may be used to check paint consistency in the applicator's container for compliance with product specification. Limited use of thinner under specific conditions may be approved by the contracting

officer's representative to overcome a peculiar job condition or to prepare the paint for conventional air spray painting. Approved use of thinner will not be in excess of one pint of thinner per gallon of paint unless the particular type of paint (such as vinyls, SSPC-Paint Specification Nos. 8 or 9) requires more thinner for proper application. The use of thinner for any reason will not relieve the contractor from obtaining specified coating coverage and film thickness. Primer coats may be tinted as designated by the contracting officer's representative.

NOTE 2: The dry film thickness of the primer shall be greater than the nominal anchor pattern depth of the surface as measured by surface profile gage.

4.6.2 Brushing

Brush application of paint shall be in accordance with the following:

4.6.2.1 Brushes shall be of a style and quality that will enable proper application of paint (round or oval brushes are generally considered most suitable for rivets, bolts, irregular surfaces, and rough or pitted steel. Wide, flat brushes are suitable for large flat areas, but they should not have a width over five inches).

4.6.2.2 The brushing shall be done so that a smooth application as nearly uniform in thickness as possible is obtained.

4.6.2.3 Paint shall be worked into all crevices and corners.

4.6.2.4 There shall be a minimum of brush marks left in the applied paint.

4.6.2.5 Surfaces not accessible to brushes shall be painted by spray, daubers, or sheepskins.

4.6.3 Spraying

All spray application of paint whether air spray, airless, or hot spray shall be in accordance with the following:

4.6.3.1 The equipment used shall be capable of properly atomizing the paint to be applied and shall be equipped with suitable pressure regulators and gages. The equipment shall be kept in such condition as to permit proper paint application.

4.6.3.2 Paint ingredients shall be kept properly mixed in the spray pots or containers during paint application either by continuous mechanical agitation or by intermittent agitation as frequently as necessary.

4.6.3.3 Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before applying paint to the surface being painted.

4.6.3.4 Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern shall be adjusted so that the paint is deposited uniformly. During application, the gun shall be held perpendicular to the surface and at a distance which will insure that a wet layer of paint is deposited on the surface.

4.6.3.5 Blind sides of all rivets, bolts, and all other areas inaccessible to the spray gun shall be painted by brush; if not accessible by brush, daubers or sheepskins shall be used. Brushes shall be used to work paint into cracks, crevices, and blind spots which cannot be painted by spray.

4.6.3.6 Particular care shall be observed with respect to type of thinner, amount of thinner, paint temperatures, and operating techniques in order to avoid deposition of paint which is too viscous, too dry, or too thin when it reaches the receiving surfaces.

4.6.4 Airless or high pressure spray application of paint shall be in accordance with all of the provisions of paragraph 4.6.3 and, in addition, shall comply with the following:

4.6.4.1 Fluid tips shall be of orifice size and fan angle as recommended by the manufacturer of the material being sprayed and the equipment being used.

4.6.4.2 The regulated pressure to the paint pump shall be adjusted so that the paint pressure to the gun is proper for optimum spraying effectiveness. This pressure shall be sufficiently high to atomize the paint. Pressures considerably higher than those necessary to properly atomize the paint shall not be used.

4.6.4.3 Spraying equipment shall utilize filters in the high pressure line so that dirt, dry paint, oil, and other foreign materials are not deposited in the paint film. Spray equipment shall be kept sufficiently clean to avoid build-up of these materials in the filter. Enough paint should be initially pumped through the system so that any cleaning solvents left in the equipment shall be completely removed.

4.6.4.4 Airless paint spray equipment shall always be provided with an electrical ground wire in the high pressure line between the gun and the pumping equipment. Further, the pumping equipment shall be grounded to avoid the build-up of any electrostatic charge on the gun, as may occur when certain types of materials are sprayed.

4.6.5 Roller coat application may be used on flat or slightly curved surfaces or over blast cleaned or pickled surfaces or over primed surfaces. Unless specifically authorized or unless the paint over such areas is subsequently brushed out, roller coat application shall not be used in application of primer over hand tool cleaned, power tool cleaned, or irregular surfaces such as rivets, bolts, crevices, welds, corners, or edges.

4.6.6 Ferrous Surfaces

NOTE 2: The following provisions are to be used for routine painting, where no peculiar problems have been noted. For corrosive atmosphere or application methods or specific coating systems, use specifications in Steel Structures Painting Council Manual, volume 2. Applicable sections of these specifications should be quoted in the contract specification to provide inspectors and other contract officials with ready access to the provisions of the contract.

4.6.6.1 Particular care shall be taken to prevent the contamination of cleaned surfaces with salt, acids, alkali, or other corrosive chemcials before the primer is applied and between applications of the remaining coats of paint. Such contaminants shall be removed from the surface. The pretreatment of prime coat shall be applied immediately after the surface has been cleaned. Succeeding coats shall be applied before contamination of the under surface occurs.

4.6.6.2 Cleaning and painting shall be so programmed that detrimental amounts of dust or other contaminants do not fall on wet, newly painted surfaces. Surfaces not intended to be painted shall be suitably protected from the effects of cleaning and painting operations.

4.6.6.3 On structures that are known to have been originally pretreated with a zinc chromate wash primer pretreatment, the cleaned areas shall, unless otherwise specified, be similarly pretreated before applying the primer paint.

4.6.6.4 First application of other than vinyl-type wash coatings shall be applied by brush, except where the item has been shop primed or field primed. The first application may be applied by brush, roller, or spray. Subsequent applications may be applied by brush, roller, or spray. Vinyl-type wash coating may be applied by brush, spray, or swab.

4.6.6.5 Vinyl-type wash coating shall be applied at a rate of maximum practical wet film thickness. Care shall be exercised in spray application to avoid the deposition of dry particles on the surface. A wet spray shall be maintained at all times. Surfaces treated with the wash coat shall be permitted to dry for not less than one hour and shall be coated as soon thereafter as

practicable, but within 48 hours after application and before any deterioration or accumulation of dust or dirt.

4.6.6.6 The types of paints used for steel stacks and other ferrous surfaces subject to elevated temperatures are indicated in the Painting Schedule. Follow the manufacturer's instructions for curing coatings applied to surfaces subject to elevated temperatures.

4.6.6.7 The entire interior of (all) (new) (existing) petroleum storage tanks shall be coated in accordance with the following requirements:

4.6.6.7.1 The coating material shall be an epoxy coating system conforming to specification MIL-C-4556. The coating system shall consist of a primer coat and two or more finish coats as required to achieve a total dry film thickness of not less than 7 mils (0.18 mm).

4.6.6.7.2 Zinc rich primers shall be applied at a coating thickness according to the manufacturer's recommendations. Application of these primers shall strictly follow the manufacturer's recommendations for suitable film thickness because too thick a film as well as too thin a film may both lead to premature failures. Follow manufacturer's directions for proper curing time of the zinc primer before application of any topcoat. Follow manufacturer's recommendations for application of a mist coat directly over the cured zinc rich primer.

4.6.6.7.3 The primer coat shall be applied as soon as possible after the blast cleaning. In no case will the time interval exceed 8 hours. If any visible rusting does occur after blasting, regardless of the time interval, the surface shall be reblasted prior to applying the primer coat. The application shall not be done when the steel surface temperature is less than 2°F (1°C) above the dew point temperature of the surrounding air. This condition will most likely occur in underground tanks. In such cases heated air shall be circulated through the tank as required to maintain this 2°F (1°C) temperature differential and thereby prevent condensation of moisture on the tank surface.

4.6.6.7.4 The coating system shall be applied by experienced applicators in strict conformance with the manufacturer's recommendations. A manufacturer's representative shall be present during the initial phase of the application. Curing instructions and safety precautions shall be rigidly followed.

NOTE 3: Shop-fabricated tanks shall be interior coated by the tank manufacturer prior to delivery. Field fabricated tanks shall be coated in the field after completion of the tank. Approval to coat the interior of existing tanks must be obtained from HQ

USAF/LEEES on an individual basis as required by AFM 85-16. Also reference should be made to existing tanks, which will be written into these specifications. These tanks, when authorized, shall be interior coated as described above for new tanks except for floating roof tanks with metallic sealing rings. The interior coating of tanks with metal-to-metal roof seals requires special consideration, and specifications for lining this type of tank shall be obtained from HQ USAF/LEEES.

4.6.7 Miscellaneous Applications and Special Requirements

4.6.7.1 Vinyl Paint Systems

Vinyl and vinyl-alkyd paints are not compatible with conventional paints and shall not be used on conventionally primed surfaces or surfaces shop coated with ferrous metal primer or a manufacturer's standard rust inhibiting primer.

4.6.7.1.1 Vinyl-Resin Paint VR-3:

Application	Application Method	Minimum Drying Time
1	Brush	12 hours
2	Spray	12 hours
3	Spray	12 hours if a fourth lamination is to be applied or at least 10 days before placing in service if only 3 laminations are used.
4	Spray	At least 10 days before placing in service.

The paint shall be applied in three of four applications. The overall total dry thickness of the three application systems will be from 5 to 7 mils. The overall total dry film thickness of the four applicatin system will be from 6 to 8 mils.

NOTE 4: As a guide, 225 square feet per gallon 95.5 m^2/ℓ) per application usually gives a dry film thickness of about 1.7 mils, (0.04 mm) but is not required to do so by the materials specifications. Variables such as surface roughness, application technique, amount of overspray, etc., affect the final spreading rates obtained. Use the four application systems for severe to the most severe environments. Use the

three application system for moderately severe corrosive conditions.

4.7 MISCELLANEOUS

4.7.1 Lettering shall be provided as scheduled on the drawings, and shall be of the (Block) (Gothic) type, and shall be (black enamel) (water-type decalcomanias finished with a protective coating of spar varnish). Letters shall conform to approved samples and shall be executed by craftsmen skilled in this type of work.

4.7.2 Contractor will repaint number, symbols, arrows, etc., after surfaces on which these items exist have been finish-painted.

4.7.3 Following completion of painting of each space, removed items, listed under Section 3, Cleaning, Preparation, and Pretreatment of Surfaces, shall be reinstalled by workmen skilled in the trade involved.

4.7.4 This project is on, or adjacent to, a civil or military airfield; hence, consult the regulations of AFM 86-8, Airfield Space Criteria, and specify any structure by name which was found to be an obstruction to flying. Include obstruction painting of such structures as towers and elevated tanks in the respective section.

NOTE 5: Review drawings to insure specification and drawings are in accord. Building(s) shall be painted in the pattern prescribed by AFM 88-16, Standards for Marking Airfields. International orange and white colors shall be used for obstruction markings.

4.8 CLEANING

Cloths and cotton waste that might constitute a fire hazard shall be placed in closed metal containers or destroyed at the end of each day. Upon completion of the work, staging, scaffolding, and containers shall be removed from the site or destroyed in an approved manner. Paint spots, oil, or stains upon adjacent surfaces shall be removed and the entire job left clean and acceptable.

4.9 ORDER OF WORK

4.9.1 General

The contractor will present to the Contracting Officer a progress schedule listing the dates he proposes to begin work in each area, as shown on the contract drawings or otherwise indicated in contract documents. The contractor will limit his activities to one area at a time and will complete all work items therein before commencing operations in a succeeding area.

4.9.2 Deviation from Order of Work

If the contractor's work has progressed to the point, in a given area, where the work remaining can be accomplished by a reduced labor force, the contractor may request approval in writing from the contracting officer to begin work in a succeeding area. The contractor will not begin work in a succeeding area until he has received written approval from the contracting officer.

SECTION 5

PAINTING SCHEDULE

5.1 PAINTING SCHEDULE

Except as specified under paragraph Surfaces Not To Be Painted, the surfaces listed in Table A, PAINTING SCHEDULE, shall receive the surface preparation, paints, and number and thickness of coats prescribed. New piping shall not be painted until it has been tested and approved. Explanatory information for use with the painting schedule is as follows:

5.1.1 Shop-Painted Items

Surfaces of fabricated and assembled items that are finish-painted by the manufacturer or specified to be finish-painted under other sections of the specifications are exempted from the following schedule requirements for surface preparation and painting. Shop-primed items shall receive surface preparation and finish painting as required by this section.

NOTE 1: Incorporate the PAINTING SCHEDULE into the contract specifications. Delete surfaces not occurring in the project or not required to be painted from the PAINTING SCHEDULE and the contract drawings. If specific finish coatings are required for specific areas, show such requirements in a PAINTING SCHEDULE. Where applicable, list the specific items to receive a particular paint system under the appropriate heading in the SURFACE AREA column of the PAINTING SCHEDULE. List surfaces requiring coating in the PAINTING SCHEDULE, and designate the surface preparation, pretreatment, and coating specification for such surfaces. Table B is a paint selection menu that should be used to select the five combinations of surface preparation and coating systems for particular surface conditions.

5.1.2 Colors and Tints

Colors and tints shall match the respective color specimens selected by the contracting officer from Federal Standard 595 color. Undercoats shall vary slightly in color from the color of the next coat.

5.1.3 Surface Preparation and Pretreatment

Surface preparation and pretreatment prior to painting shall be accomplished as required by Section 3 of this specification.

TABLE A

PAINTING SCHEDULE

Bldg. No.	Surface Area to be Painted (Ft^2)	Surface Preparation Treatment	1st Coat	2nd Coat	3rd Coat	4th Coat	Areas not to be Painted

TABLE B

PAINTING SELECTION MENU*

SURFACE	SURFACE PREPARATION	1ST COAT**	2ND COAT***	3RD COAT***	4TH COAT**
Exterior ferrous surface subject to moderate to severe atmospheric exposure	Near white metal blast cleaning, S.S.P.C. SP 10	V R - 3 (vinyl) (1.5 mil)	V R - 3 (1.5 mil)	V R - 3 1.5 mil)	V R - 3 1.5 mil)
	Near white metal blast cleaning, SSPC - SP 10	MIL-P-23236 (Inorganic zinc, silicate) Type I, Class 3 (3.5 mil)	V R - 3 (1.5 mil)	V R - 3 (1.5 mil)	
	Commerical blast cleaning, SSPC - SP 6	MIL-P-23377 (Epoxy polyamide) (2 mil)	MIL-P-23236 (Urethane) Type I, Class 4 (2 mil)		
Exterior ferrous surfaces subject to high temperature exposures	Commerical blast SSPC - SP 6	TT-P-28 (to 1200°F) (Aluminum) MIL-P-14104 (to 1400° F) Silicon frit (2 mil)			
Exterior galvanized steel surfaces subject to moderate to severe atmospheric exposure	On new surfaces, solvent clean, SSPC-SP-1	MIL-P-15328 (Pretreatment coating) (0.3 mil)	MIL-Pa-23377 (Epoxy polyamide) (2 mil)	MIL-P-23236 (urethane) (2 mil)	
	On painted surfaces remove old paint by brush off blast cleaning, SSPC-SP 7 or high pressure water blast cleaning	MIL-P-23377 (Epoxy polyamide) (2 mil)	MIL-P-23236 (Urethane) (2 mil)		
Interior ferrous	Near white metal blast cleaning SSPC-SP 10	V R -3 (1.5 mil)	V R - 3 (1.5 mil)	V R -3 (1.5 mil)	V R -3 (1.5 mil)
		MIL-P-24441 (Epoxy) (2 mil)	MIL-P-24441 (2 mil)		
Interior ferrous fuel tanks	Near white metal blast cleaning SSPC-SP 10	MIL-C-4556 (Epoxy) (3.5 mil)	MIL-C-4556 (3.5 mil)		

* The complete coating system, e.g., primer, topcoat, will be furnished by one manufacturer, the system must be submitted as a family. When a bid is submitted, the bidder must indicate the manufacturing source. The paint films to be applied at manufacturer's recommended dry film thickness. Dry film thickness application shall not be more than 1 mil greater than manufacturer's recommendation.

*0 1 mil = 25.4 μm

TABLE C

COLOR CODE MARKING SCHEDULE

Piping	Surface Area to be Painted (Ft^2)	Color		Location of Identification Markings	Remarks
		Primary	Secondary		

5.1.4 Color-Code Marking

Piping will be color-coded in accordance with Military Standard 101, Color Codes for Pipelines and Compressed Gas Cylinders, Military Standard 161, Identification Methods for Bulk Petroleum Products Systems including Hydrocarbon Missile Fuels, and Military Standard 172, Color Code for Containers of Liquid Propellants.

Marking for piping systems shall be provided as specified in Table C. Paint shall be separately specified for insulated and uninsulated piping.

APPENDIX B

AIR FORCE PAINT INSPECTOR'S GUIDE

OVERVIEW

It has been estimated that the total cost of corrosion in the U.S., is $70 billion annually and that corrosion maintenance costs for real property in the Air Force is $300 million per year. An appreciable proporation of these losses are related to atmospheric corrosion which occurs after coating failure on steel structures. To protect the steel structure against atmospheric corrosion, the most appropriate coating system must be used. Every coating operation includes coating selection, surface preparation, and proper application. Also, each phase of the operation is completely dependent on good inspection. Thus, the inspector is the key to the success (or failure) of every coating operation.

This inspector's guide has been developed to aid the paint inspector carry out his task more efficiently. It has been written specifically for painting (coating) of high value steel structures (e.g., steel buildings, water towers, fuel storage tanks, and observation towers.

This inspection guide is divided into the following six sections:

- INSPECTION REQUIREMENTS
- INSPECTOR'S RECORDS
- COATING MATERIALS
- SURFACE PREPARATION
- COATING APPLICATION
- APPROVAL PROCEDURES

INSPECTION REQUIREMENTS

The paint inspector should participate in the following functions: (1) prebid conference(s) where the inspection procedures are outlined; (2) surface preparation inspection(s); (3) coating application inspection(s); and (4) final approval inspection(s). The specification writer is responsible for the materials selection; the project engineer is responsible for the technical requirements and instructions; and the inspector is responsible for enforcing the provisions of the coating specification--he is the policeman.

Inspection of coating materials (e.g., compliance to specification requirements) is performed by a testing laboratory. Inspection of

coatings applied to structural steel is generally accomplished by either visual or instrumental means. Appendix 1 illustrates a matrix of paint inspection tools useful for the inspection process involving surface preparation, application, and final approval. Appendix 2 lists the inspector's tools with descriptions and sources.

INSPECTOR'S RECORDS

While not an inspector's tool per se, the inspectors record book is most important. The maintenance of a record book containing all transactions between the inspector and the contractor is essential to eliminate or minimize any contract disputes. At the start of the work, the contractor must provide the inspector with the paint manufacturer's direction. These directions include paint type, thinner to be used, mixing ratios used, recommended application thickness, recommended primer, tie coat, topcoat, topcoat system as applicable, recommended time between coating application, recommended surface preparation requirements, recommended application temperatures, recommended methods of application, and any special or unusual precautions to be followed. These directions should be maintained as part of the inspector's records for the contract.

Guidance on inspector's records and samples of record forms are given in AFM 85-3 and this guide. The daily project report is to be dated each day with no blank spaces left. The documentation is necessary in case of contract dispute or legal action by or against the contractor. A daily project report modified from AFM 85-3 for use with the model specification is attached as Appendix 3.

Photographs of the test panel used as a standard of surface preparation and of the test panel used as a standard of paint application are essential parts of the inspector's records for the contract. Also, the inspector should take photographs of any part of the painting inspection process (e.g., surface preparation, paint application, approval of the completed job, etc.) where the possibility of a contract dispute or legal action by or against the contractor exists. The photographs will include a legible card which indicates date, project number, project title, building number, and location and a ruler to indicate the scale. A brief description of the picture's contents should be included on the back side of the photograph.

COATING MATERIALS

The paint inspector is not expected to be a coatings consultant, analytical chemist, or a coatings formulator, but he should have a basic knowledge about paint materials. Chapter 6 of AFM 85-3 provides the inspector with a basic knowledge of these materials, and Chapter 4 provides general information on paint materials with regard to sampling, storage, conditioning and mixing, straining, and thinning.

Specific checklist items useful to the inspector which relate to coating materials are listed as follows:

- Materials must conform to the requirements of the specification designated in the contract as determined by testing a quart sample in one of the laboratories listed in Appendix 4.
- Testing is required for quantities of paint in excess of 20 gallons (75.7 ℓ) or where the sensitivity or critical aspects of the area in which the work is to be performed necessitates testing of paint material of lesser value.
- Select and forward test samples in accordance with paragraph 1.10 of the model specification (Appendix A) with the cost of testing to be billed to the contractor in accordance with paragraph 1.10.1.
- The paint inspector in the presence of the contractor will take two one-quart samples from each batch by random selection of sealed containers. One quart shall be sent out for testing, and one quart will be retained for reference for a period of one year from the date of final approval of the contract work.
- The paint inspector in the presence of the contractor will measure the efflux viscosity of a randomly selected paint sample by the use of a Zahn dip-type viscosity cup. The viscosity measured will become part of the inspector's records and will be used as a reference standard.
- Allowances of at least <u>one month</u> should be made for the materials to be tested before paint operations begin.
- Paints must be in sealed, unbroken containers that plainly show the date of manufacturer, manufacturer's name and instructions, specification number/or designated name, batch number, and Fed. Std. 595 color.
- Paints must be furnished in containers not larger than 5 gallons (18.9ℓ) capacity.
- All paints in a coating system should be obtained from the same manufacturer.
- To estimate quantities of paint required for a job, use Techdata Sheet 76-03, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, California 93043, for guidance. (See Appendix 5.) This publication includes a nomograph with which material requirements can be estimated. This measurement can provide a convenient check to determine if a contractor has procured sufficient

paint for a job (by counting full cans at the job site) or has applied sufficient paint (by counting empty cans).

- Paint materials should be stored on site in an approved contractor furnished building of sufficient size to contain all painting materials, and the building should be capable of maintaining a minimum temperature of 50°F.

SURFACE PREPARATION

Surface preparation is the most important factor affecting the performance of the paint system. There are many methods of surface preparation available, and these are discussed in Chapter 4, AFM 85-3 and Appendix 6 contains a tabulation of surface preparation methods recommended for high value steel structures. It should be noted that hand tool cleaning SSPC-SP2 is not included since this method is not recommended for high value steel structures.

A test panel must be prepared by the contractor to be used as a standard of surface preparation. The test panel shall be approximately 4 foot by 4 foot (1m by 1m) section of the structure to be painted. The degree of surface preparation shall be approved by the contracting officer or his delegated representative before surface preparation is continued. The appearance should be compared with the required pictoral standard in SSPC-Vis 1 or the visual blasted steel encapsulated panels provided by NACE (TM-01-70 for sandblasted panels and TM-01-75 for grit and shot blasted panels). The inspector will take photo-graphs of the cleaned and approved test panel which shall become part of the inspection record. The surface profile will be determined by the Keane-Tator comparator or the use of Testex Press-O-Film, whereby a permanent record of the surface profile is made.

Specific checklist items useful to the inspector which relate to surface preparation are listed as follows:

- Prior to cleaning, welds, weld spatter, and burrs must be smoothed. Sharp edges or protrusions should be grounded smooth. Voids from cracks, crevices, back-to-back angles, etc., must be filled. (See Section 3 of the Model Specification.)

- Prior to blast cleaning, inspect for visible oil, grease, weld flux, chalk on old painted surfaces, etc. Rub the surface with a clean rag to inspect for cleanliness. If the surface is not clean, clean by solvent cleaning (SSPC-SP1) or by high pressure water cleaning with a detergent additive.

- The degree of blast cleaning should be compared to the description given in the appropriate SSPC specification,

and the appearance should correspond with the pictoral standards of SSPC-Vis 1 (see Section 2) or NACE panels as specified.

- Blast cleaning operations should be performed in a manner that no damage is done to partially or entirely completed portions of the work, adjacent surfaces, or equipment.

- Blast cleaning should progress from the top towards the bottom of a structure, should be carried on downwind from any recently painted structures, and should not scatter abrasive on or into surrounding buildings or equipment.

- Blast-cleaned surfaces must be examined for any traces of oil, grease, etc. not removed by blast cleaning or introduced by the blast equipment. If present, the contaminants must be removed by solvent cleaning (SSPC-SP1).

- Dry abrasive blast cleaned surfaces must be cleaned by vacuum or air blast to remove any traces of blast products from the surface or pitted areas.

- Maintain a photographic record of surface preparation.

- After cleaning, one coat of ferrous metal primer must be applied to ferrous surfaces to receive paint not to exceed 8 hours after the surface preparation. Any cleaned surface face on which rust forms prior to application of paint must be blast cleaned again. The cleaning should proceed by small enough areas or units of work, that the cleaning be completed, inspected, and accepted and the primer applied within the 8-hour time requirement.

APPLYING THE COATING

There are four important reasons why paint coatings fail prematurely: (1) the surface is not clean, (2) insufficient paint has been applied (although too much paint applied can cause premature failure), (3) poor workmanship in applying the paint, and (4) the paint used is of inadequate quality or of unsuitable type. General guidance on paint application is discussed in Chapter 4 of AFM 85-3 in the SSPC painting manuals, Volumes 1 and 2, and in Industrial Maintenance Painting published by NACE. Also, SSPC-PA1 is a specification for the application of paint. Special precautions are essential for POL or water storage tanks which contain fluid at temperatures above or below ambient temperatures.

Paint systems used for structural steel will not dry or cure properly under extremes of temperature or at high humidity, nor will they adhere if applied over wet surfaces. Temperature limits will generally be included in the specification and usually are >40°F and <95°F (>4.4°C and <35°C), and humidity limits are often set at

an 85 percent RH upper limit and wind velocities are often set at a 15 mph (24 km/h) maximum. Painting should not be undertaken in rain, snow, fog, or mist, when the surface is covered with frost, or when the temperature of the metal surface is below the dew point. The dew point can present problems in the early mornings in spring and fall. Use of a sling psychrometer is invaluable to measure relative humidity and dew point. Surface temperature thermometers are also important paint inspector's tools. If paint has to be applied in damp or cool weather, the steel must be painted under cover and the steel heated to a satisfactory temperature for paint application.

A test panel must be prepared by the contractor to be used as a standard for paint application. The test panel shall be an approximately 4 foot by 4 foot section of the structure to be painted. The same panel area used as a standard for surface preparation may be used as the substrate for paint application. The wet and dry thickness and film continuity shall be tested by inspector's tools agreed to by contractor and contracting officer. The paint application shall be approved by the contracting officer or his delegated representative before paint application is continued. Photographs of the approved panel shall become part of the inspection record.

Specific checklist items useful to the inspector which relate to paint application are listed as follows:

- Since no paint operation should begin until weatner conditions are suitable, a sling psychrometer or equivalent, psychrometric tables, and surface thermometer will be used to verify suitable weather conditions. The specifications require that the surface be 2 to 5°F (1 to 2°C) above the dew point. (See Section 3 of the Model Specification.) Appendix 7 contains a tabulation of relative humidities and dew points.

- Ensure that application equipment is used as specified and is acceptable for the type of coating applied. (For guidance, see AFM 85-3 or follow equipment manufacturer's directions.)

- Ensure that proper ventilation of tanks and other enclosed areas is available where coating is to be applied and cured. Adequate ventilation is necessary to minimize fire and toxicity hazards and for proper cure of the coatings.

- The required contents of the manufacturer's direction concerning paint type, recommended minimum and maximum thicknesses, recommended time between coats, recommended primer-topcoat system, thinner to be used, and any other special or unusual precautions to be used, will be a part of the inspector's records for the contract.

- Paint must be kept properly mixed in spray pots or containers during paint application, either by continuous mechanical agitation or by intermittent agitation. This is especially important with zinc-rich primers which tend to settle readily. Also, some two-component epoxies must be allowed to stand for approximately 30 minutes before application begins, and some coatings have limited pot life. Follow manufacturer's directions for mixing and length of pot life.

- Thinning of the paint must follow manufacturer's instructions both with regards to type solvent used and amount of solvent to be used.

- Field examination for the viscosity of the paint should be made with effux viscometers or weight per gallon may be determined by weighing a one gallon sample of paint obtained from an opened field sample in the presence of the contractor. Viscosities should be measured from a sample taken at the point of application, i.e., the spray gun nozzle, or the container used for brush or roller application, and compared to the viscosity of the reference sample.

- Contract specifications require a minimum and maximum dry film thickness for each coating application. (See Section 5, Painting Schedule of Model Specifications.) Wet film and dry film thickness gages are useful tools for thickness measurements. Wet film gages can be used as a guide to estimate the dry film thickness by multiplying the measured wet film thickness by the percent (as a decimal fraction) nonvolatile volume. Readings are dependent on time of measurement after application and thinner, since solvents are rapidly evaporating as the paint dries. However, use of the wet film thickness gage allows remedial action to be taken at the time the coating is applied.

- Examine each coating for completeness of cure. Guidance for drying time is given in Federal Test Method Standard No. 141B, method 4061, and also by the paint manufacturer's directions. After cure, measure and record the dry film thickness of each coating layer. Wrinkling, lifting, or loss of adhesion is cause for rejection of the coating.

- Time between application of successive coats of paint shall not be less than, or exceed, the manufacturer's directions which the manufacturer must provide at the start of the work.

- Examine the cured coating for visual defects with the aid of a hand magnifying lens, 20X. The individual defects

of blisters, bubbling, fish eyes, orange peel, runs and sags, dry spray contaminants, mechanical damage, color and gloss uniformity (topcoat only) may be interpreted with pictorial guides available from ASTM. (See Appendix 2 for specific ASTM refrences. These defects are also illustrated in Chapter 5 of AFM 85-3.)

- Examine for pinholes and mechanical damage of each coating layer with a holiday detector. Repair exposed area(s) by application of primer and topcoat, as required before application of the next coat.

- Selected photographs of the painting process during application and after completion shall become part of the inspection record.

- To summarize, the inspection report of the coating application and the appearance and performance characteristics of the applied paint film should note any of the following deficiencies:

	Coating System		
Deficiency	Inorganic Zinc Primer	Organic Primer	Organic Topcoat
• Application process			
runs and sags	X	X	X
dry spray	X	X	X
contaminants	X	X	X
uniformity	X	X	X
• Applied film			
dry film thickness	X	X	X
curing properties	X	X	X
mechanical damage	X	X	X
adhesion	X	X	X
mud crack	X		
orange peel		X	X
blistering		X	X
pinholes		X	X
color and gloss		X	X
uniformity			X

Approval Procedures

If the inspection requirements have been followed stepwise, the final approval procedure of the inspector should be routine. The inspector's tools listed for the examination of the dry paint film in Appendices 1 and 2 and in the previous sections should be used for spot-checking the completed job for approval. However, this

final approval procedure is most important since it must be determined that any earlier deficiencies have been corrected. Since the coating functions as a barrier against corrosion and since the protection of a ferrous surface is directly related to coating thickness and continuity, measurements for coating thickness and continuity are essential.

The following checklist can be used to inspect the final job:

- Examine the cured coating system for visual defects with the aid of a hand magnifying lens, 20X. The thickness of any loose paint chips should be measured by micrometer. The individual defects of rusting, blisters, bubbling, fish eyes, orange peel, runs and sags, spray contaminants, mechanical damage, color and gloss uniformity of the topcoat may be interpreted with pictoral guides available from ASTM. Also, these defects are illustrated in Chapter 5 of AFM 85-3.

- Selected photographs of the completed job shall become part of the inspection record. Photograph the observed visual defects. Photographic records are important where there is a possibility of a contract dispute or legal action by or against the contractor.

- Measure and record the total dry film thickness by the magnetic or optical (Tooke) gages. When the Tooke gage is used, the coating must later be repaired, since the coating is cut through to the substrate for the thickness measurement.

- Examine for pinholes, mechanical damage, and any other areas where the ferrous substrate is exposed by the use of a holiday detector.

- When loose paint, blisters, bubbling, etc. are observed during the visual examination of the completed job, adhesion of coating to substrate is suspect. Measure adhesion of flat surfaces near the questionable area(s) with an Elcometer Adhesion Tester. Forces of less than 100 psi (2.6MPa) to remove the coating means that these area(s) should be recoated. The coating is damaged when using this instrument and must later be repaired. When it is not convenient to use the Elcometer Adhesion Tester, a tape adhesion test should be used; procedures are given in ASTM D 3359.

Since the "Air Force Model Guide Specificatin for Painting High Value Steel Structures" includes a written guarantee provision unconditionally guaranteeing the new coating to be free of any physical defect or deterioration for three years, periodic inspection is necessary. The inspector should make periodic inspections

APPENDIX 1. MATRIX OF PAINT INSPECTOR'S TOOLS FOR SURFACE PREPARATION, PAINT APPLICATION AND FINAL APPROVAL

Inspection Process	Tools *												
	Camera, Polaroid, Color	SSPC-Vis 1	NACE TM-01-70, TM-01-75	Keane-Tator Comparator	Testex Press-O-Film	Clean rags	Sling psychrometer, surface thermometer	Wet film thickness gage	Dry film thickness gage	Magnifying lens	Holiday Detector (Elcometer)	Adhesion Tester (Elcometer)	Zahn Dip-type Viscosity Cup
Surface Preparation													
Appearance	X	X	X							X			
Surface profile				X	X								
Residual contamimants						X							
Adhesion of existing paint												X	
Paint Application													
Temperature, R.H.							X						
Dew point							X						
Paint viscosity													X
Wet film thickness								X					
Dry film thickness									X				
Appearance	X												
Film defects, voids, etc.											X		
Adhesion												X	
Final Approval		X							X	X	X	X	

* A description of tools is given in Appendix 2. Certain commercial equipment has been identified in order to adequately test coating systems. In no case does identification imply recommendation or endorsement by the National Bureau of Standards or the U.S. Air Force, nore does it imply that the equipment is necessarily the best equipment available for the purpose.

APPENDIX 1. MATRIX Of PAINT INSPECTOR'S TOOLS FOR SURFACE PREPARATION, PAINT APPLICATION AND FINAL APPROVAL (CONCLUDED)

Inspection Process	Tools *
Surface Preparation	
Appearance	
Surface profile	
Residual Contaminants	
Adhesion of existing paint	
Paint Application	
Temperature, R.H.	
Dew Point	
Paint viscosity	
Wet film thickness	
Dry film thickness	
Appearance	
Film defects, voids, etc.	
Adhesion	
Final Approval	

* A description of tools is given in Appendix 2.

APPENDIX 2. GUIDE TO INSPECTION TOOLS

Tool	Description	Source*	Approximate Cost
Tools for Paint Materials			
Directory , U.S. Government Inspection Services and Testing Laboratories, July 1976 (see also Appendix 4)	Testing of government testing laboratories and services in specific areas, e.g., paint testing	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402	$2.45
Techdata Sheet 76-03, "How to Estimate Qualities of Paint Required for a Job" (see also Appendix 5)	Description of how to calculate amounts of paint required; nomograph information and pocket sized slide rule available	R.W. Drisko, Code L52, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, CA 93043	-
Tools for Surface Preparation			
SSPC-Vis 1 Standard	Book of colored prints which illustrate the degrees of hand, power tools and blast cleaning of structural steel and the various rust grades, used for the visual examination of the degree of rust removal	Steel Structures Painting Council, 4400 5th Ave, Pittsburgh, PA 15213 3	$55
NACE TM-01-70 and TM01-75 Standards	Sand blasted steel panels (TM-01-70) and shot and grit blasted panels (TM-01-75) encapsulated in plastic, used for the visual examination of the degree of rust removal	National Association of Corrosion Engineers, Katy, TX 77450	TM-01-70 $75 TM-01-75 $150
Surface Profile Gage (Keane-Tator Comparator)	Field instrument to determine the surface profile of blast cleaned surfaces, comparator discs have sections with nominal anchor pattern depths of sand, metallic, grit and shot blast cleaned surfaces.	3	$200
Surface Profile Gage (Press-O-Film Tape)	Mylar® Press-O-Film is rubbed onto the blast cleaned surface forming a reverse image of the profile, replica is measured with a micrometer to determine maximum peak to valley height	3	$80

APPENDIX 2. GUIDE TO INSPECTION TOOLS (CONTINUED)

Tool	Description	Source*	Approximate Cost
Polaroid Camera	Portable camera which takes instant photographs to record test panels, unusual areas of surface preparation, etc. The photographs shall become part of the inspection record and are to be signed and dated by the inspector and contractor	Local purchase	$100
Tools for Paint Application			
Sling psychrometer, or equivalent	Instrument consists of dry and wet bulb thermometers for determination of dew point, temperature and relative humidity; used in conjunction with psychrometric tables 235	3, Standard psychrometric tables 235 may also be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402	$28 + $1.20 for psychrometric tables 235
Surface Thermometer	Thermometer designed to measure surface temperatures	1,2,3	$4-12
Zahn dip-type viscosity cups	The instrument is a bullet-shaped stainless steel cup which delivers about 45 ml of liquid sample through a precisely drilled orifice at the bottom of the cup. Cup No. 1 for thin liquids, e.g., solvents Cup Nos. 2 and 3 for mixed paints	1,2	$45 each
Wet film thickness gage	Notched flat planel, notches of various sizes calibrated in mils and microns, held at right angle (90°) to the surface and applied immediately after coating application	1,2,3	$12
Dry film thickness Approximate Permament magnet inspector thickness gage (e.g., Elcometer, Microtest)	Measures dry film thickness of non-magnetic material on a ferrous base, shim calibrated thickness read directly from scale; procedures for measurement are given in SSPC-PA2 and ASTM G12	1,2,3	$125-300 + SSPC-PA2 ASTM G12

APPENDIX 2. GUIDE TO INSPECTION TOOLS (CONTINUED)

Tool	Description	Source*	Approximate Cost
Dry film thickness gage Optical thickness gage (Tooke)	Measures thickness on all sub strates by 50% illuminated microscope, destructive to coating as cutting tips penetrate into substrate, measures thickness of individual coats, intercoat contamination, voids, etc.	1,2,3	$250
Method 4061, Drying Time	Method 4061 describes methods for measuring the drying and curing of organic coatings	Federal Test Method Std. No. 141B Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402	$3.75
Magnifying lens, 20X		Local purchase, 2,3	$20-100
Holiday Detectors	Non-destructive instrument for testing nonconductive films, portable, battery operated, low voltage for films <20 mils, noise detects where there are coating defects, voids or moisture permeable areas	1,2,3	$100
Tools for Final Approval			
Standards, i.e., ASTM D 659, ASTM D 714, ASTM D 662, ASTM D D 661, ASTM D 660	Visual standards for measurement of rusting, chalking, blistering, flaking, erosion, checking, cracking	These standards are a part of Fed. Test Method Std. No. 141B, and are therefore, available from the Naval Publications & Forms Center (NPFC) 5001 Tabor Avenue Philadelphia, PA 19120 Autovon 442-3321	-
Magnifying lens	Previously described	Previously described	
Micrometer	Instrument with adjustable opening to measure thickness of loose paint chips	1,2,3	$50
Polaroid Camera	Previously described	Previously described	
Dry film thickness	Previously described	Previously described	
Holiday detector	Previously described	Previously described	

APPENDIX 2. GUIDE TO INSPECTION TOOLS (CONTINUED)

Tool	Description	Source*	Approximate Cost
Elcometer Adhesion Tester	The instrument measures the tensile strength of adhesion of coating(s) to substrate; aluminum dolly is cemented to surface with quick setting cyanoacrylate adhesive (for field inspection), claw of adhesion tester lifted into head and the dolly is pulled off, the breaking poundage is indicated on the scale	1,2,3	$325
Standard, ASTM D 3359	Methods cover procedures for assessing tape adhesion of coating films to metallic substrates.	American Society for testing and materials, 1916 Race St., Philadelphia, PA 19103	$4.00

*1. Gardner Laboratory
Box 5728
5521 Landy Lane
Bethesda, MD 20014

2. Paul N. Garnder Co.
P.O. Box 6633, Station 9
Fort Launderdale, FL 33316

3. KTA Instruments
2020 Montour St
Coraopolis, PA 15108

APPENDIX 3. DAILY PROJECT REPORT

Date	Project No.	Project Title	Weather Condition	Ambient Temp. °F (°C)	Humidity %	Dew Point °F (°C)	Wind Velocity mph (km/h)

Bldg. No.	Type of Surface Preparation*	Surface Condition	Temp. °F (°C)			Material Applied		Method of Application**	Square Footage of Paint Applied	Total Paint Used Gal.	Spreading Rate-Sq.Ft./Gal.	Wet Film Thickness-mils	Cure Time per Coat-hrs.	Remarks
			Storage	Material	Surface	Spec.	Color							

*1. Solvent cleaning, SSPC-SP1
2. Power tool cleaning, SSPC-SP3
3. White metal blasting, SSPC-SP5
4. Commercial blast cleaning, SSPC-SP6
5. Near white blast cleaning, SSPC-SP10

**1. Brush
2. Roller
3. Conventional air spray
4. Airless spray
5. Other

at six months, one, two and three years. Most coatings defects will occur within six months of application, so this inspection is very important for final approval; repairs needed should be minimal at this time. It also should be noted that, under the provision of the guarantee, the contractor shall not be held liable for (1) any damage to the coating caused by failure of the painted structure, (2) any damage to the coating caused by abrasion or abuse from causes beyond the control and without negligence of the contractor, and (3) any damage caused by fire, lightning, or act of public enemy.

APPENDIX 4. LIST OF GOVERNMENT PAINT TESTING LABORATORIES

This list of government testing laboratories available for acceptance testing of paints is taken from the Directory, U.S. Government Inspection Services and Testing Laboratories, July 1976, General Services Administration, Federal Supply Service, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402. Price $2.45. The condition for service to other agencies is also listed.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
WATERWAYS EXPERIMENT STATION

The mailing address of this facility is P.O. Box 631, Vicksburg, MS 39180 (601-636-3111).

SERVICES TO OTHER AGENCIES: Testing will be performed for other federal agencies, state and local governments, foreign governments, and private firms on a cost reimbursable basis, provided the testing is within the normal capability of the facility and does not interfere with the facility's mission.

DEPARTMENT OF DEFENSE
DEFENSE SUPPLY AGENCY
DEFENSE PERSONNEL SUPPORT CENTER

Clothing and Textiles Laboratory
Bldg. 15
2800 S. 20th Street
Philadelphia, PA 19101
214-271-3240

SERVICE TO OTHER AGENCIES: Testing services for other than DOD agencies are restricted to a one-time courtesy service because of workload.

DEPARTMENT OF THE NAVY
MARINE CORPS

Repair Division
Marine Corps Supply Center — Eastern United States
Albany, GA 31704
912-439-5301

Repair Division
Marine Corps Supply Center — Western United States
Barstow, CA 92311
714-557-6211

SERVICE TO OTHER AGENCIES: Laboratory and testing services within the capability of each facility will be provided to other agencies, when the nature of the work does not detract from in-house product operations. These facilities operate on an industrial funding basis and will require full reimbursement for all costs incurred, based upon current labor and overhead rates.

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND
LONG BEACH NAVAL SHIPYARD

Laboratory Division
Long Beach Naval Shipyard
Long Beach, CA 90802
213-832-3311

SERVICE TO OTHER AGENCIES: Requests from other agencies will be accepted depending upon manpower and facilities available. Charges will be based on labor costs, materials, and overhead. Details of scheduling and charges will be provided upon request.

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND
NORFOLK NAVAL SHIPYARD

Chemical Laboratory
Norfolk Naval Shipyard (Code 138)
Portsmouth, VA 23709
804-397-6531

Maryland, Virginia, West Virginia Kentucky, and North Carolina

SERVICE TO OTHER AGENCIES: Requests from other agencies will be accepted depending upon manpower and facilities available. Charges are calculated individually on each request depending on man-hours and materials required. Details of scheduling and charges will be provided upon request.

DEPARTMENT OF THE NAVVY
NAVAL SHIP SYSTEMS COMMAND
PEARL HARBOR NAVAL SHIPYARD

Industrial Test Laboratory
Pearl Harbor Naval Shipyard
Building 451
Pearl Harbon, HI 610
808-474-7229

SERVICE TO OTHER AGENCIES: Requests for services from other agencies are accepted on a limited basis depending upon current workload. Charges will be based on man-hours expended, plus an overhead fee. Details of scheduling and charges will be provided upon request.

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND
PHILADELPHIA NAVAL SHIPYARD

Test Laboratory
Philadelphia Naval Shipyard
Building 121
Philadelphia, PA 19112
215-755-3243

SERVICE TO OTHER AGENCIES: Request for services from other than DOD agencies will be accepted only if work and existing staffing permits. Details of scheduling and charges will be provided upon request.

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND
PUGET SOUND NAVAL SHIPYARD

Laboratory Division
Puget Sound Naval Shipyard
Bermerton, WA 98314
206-478-3305

SERVICES TO OTHER AGENCIES: Requests for services from other agencies will be accepted subject to current workload limitations. Details of scheduling and charges will be provided upon request.

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
INSTITUTE OF APPLIED TECHNOLOGY

Center for Building Technology
Washington D.C. 20234
301-921-3375

SERVICE TO OTHER AGENCIES: Acceptance testing is performed only for agencies within the Washington D.C. area. Preliminary testing is conducted for calibration of samples, but not for the purpose of approval or disapproval. All services are performed on a reimbursable basis. Additional details on fees are contained in NBS Special Publication 250, 1970 edition, entitled "Calibration and Test Services of the National Bureau of Standards."

GENERAL SERVICES ADMINISTRATRION
FEDERAL SUPPLY SERVICE
OFFICE OF STANDARDS AND QUALITY CONTROL

Region 2 (201 Varick St., New York, NY 10014, 212-620-3301)
Region 9 (390 Main St., Rm. 7111, San Francisco, CA 94105, 415-556-0475)
Region 10 (GSA Federal Center, Auburn, WA 98002, 206-833-5321)

SERVICE TO OTHER AGENCIES: Testing services are available to other agencies upon request.

DEPARTMENT OF THE INTERIOR
BONNEVILLE POWER ADMINISTRATION

Branch of Laboratories
J. D. Ross Substation
Vancouver, WA 98660
206-693-5801

SERVICE TO OTHER AGENCIES: Occasional test work is performed for other agencies as workload and available manpower permit. Charges include all overhead costs, materials, equipment, and direct labor.

TENNESSEE VALLEY AUTHORITY
OFFICE OF ENGINEERING DESIGN AND CONSTRUCTION

Materials Engineering Laboratory
Division of Construction
Knoxville, TN 37092
615-577-7571

SERVICE TO OTHER AGENCIES: Testing services will be provided to other agencies upon request. Charges will be based upon costs plus applicable overhead.

DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF DIRECT FEDERAL PROJECTS

1000 North Glebe Road
Arlington, VA 22201
703-557-9070

Denver Federal Center
Building 40
Denver, CO 80225
303-234-4795

610 East 5th Street
Vancouver, WA 98661
206-696-4041

SERVICE TO OTHER AGENCIES: Requests for testing services are accepted subject to current work schedule. Charges will be based on actual costs involved.

DEPARTMENT OF THE TREASURY
U.S. CUSTOMS SERVICE

U.S. Customs Laboratories serve the geographical areas indicated:

408 Atlantic Avenue, Room 807 Boston, MA 02210 617-223-7709	Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut and New York.
6 World Trade Center Code 20867 New York, NY 10048 212-466-4582	Southeastern New York and New Jersey.
103 South Gay Street, Room 704 Baltimore, MD 21202 301-962-2920	Maryland, Virginia, West Virginia, District of Columbia, Pennsylvania, Deleware and southern New Jersey.
Customhouse, Room 208 1-3 Bay Street Savannah, GA 31401 912-232-4363	North Carolina, South Carolina, Georgia, and Florida
Customhouse, La Marina San Juan, PR 00903 809-723-2780 Ext. 32	Puerto Rico and Virgin Islands.

Customhouse, Room 322 423 Canal Street New Orleans, LA 70130	Northwestern Florida, Alabama Mississippi, Louisiana, Arkansas, and Tennessee.
301 Broadway San Antonio, TX 78205 512-225-4755	Texas, Oklahoma, New Mexico, and Colorado.
610 Canal Street, Room 714 Chicago, IL 60607 312-353-6128	Illinois, Indiana, Ohio, Michigan, Iowa, Nebraska, Kansas, Missouri, Kentucky, Wisconsin, Minnesota, North Dakota, and South Dakota.
300 South Ferry Street San Pedro, CA 90731 213-831-9435	Southern California and Arizona.
Appraisers Building, Room 1508 630 Sansome Street San Francisco, CA 94111 415-556-2895	Nothern California, Nevada, Utah, Idaho, Washington, Montana, Wyoming, Alaska, and Hawaii.

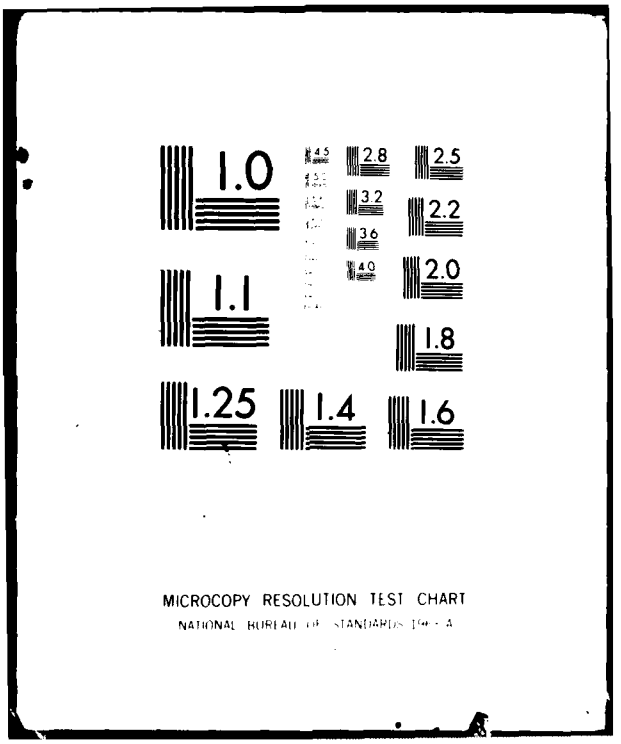
SERVICE TO OTHER AGENCIES: Testing services are provided to other agencies on a limited basis when workload and facilities permit, including court appearance of chemist performing the tests. Requests are coordinated through the Office of the Director, Technical Services Division, 1145 19th Street, NW, Washington D.C. 20229, 202-964-5853. Reimbursement depends on the nature of services performed.

AD-A099 534 AIR FORCE ENGINEERING AND SERVICES CENTER TYNDALL AF--ETC F/G 11/6
PROTECTIVE COATINGS FOR STEEL STRUCTURES; LABORATORY AND FIELD --ETC(U)
JAN 80 P G CAMPBELL, J F SEILER, G A SLEATER

UNCLASSIFIED AFESC/ESL-TR-80-20 NL

2 OF 2

END
DATE FILMED
7-81
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

TECHDATA SHEET

HOW TO ESTIMATE QUANTITIES OF PAINT REQUIRED FOR A JOB

CEL Techdata Sheet 74-11 describes the field measurement of dry and wet paint film thicknesses. Another measure of importance to Public Works personnel concerned with painting is the quantity of paint required for a particular job. In addition to providing an estimate of the material requirements, such a measurement can provide a convenient check to determine if a contractor has procured sufficient paint for a job (by counting full cans at the job site) or has applied sufficient paint (by counting empty cans).

NOMOGRAPH

By simple calculation it can be shown that a paint that has no volume change on curing (has 100% solids) will have a spreading rate of 1,600 sq ft per gal at a dry film thickness of 1 mil. When applied at a greater thickness, it will have a lower spreading rate (e.g., 800 sq ft per gal at 2 mils). Similarly, a paint that loses solvent (and, thus, volume) on curing will have a lower spreading rate per mil of dry film thickness. The simple mathematical relationship that exists between percent solids by volume, dry film thickness, and spreading rate was used to prepare the Nomograph.

Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, CA 93043

To determine the spreading rate and quantity requirements of a paint:

- Place the edge of a ruler on the value of Percent Solids by Volume (Column A).
- Keeping the ruler position on Column A, rotate the ruler until its edge crosses Column C at the desired Dry Film Thickness value.
- Read the Spreading Rate of the paint on the right-hand side of Column B where the ruler edge crosses it and the Gallons Required to Coat 1,000 sq ft at this spreading rate on the left-hand side of Column B.

Most paint suppliers provide data on the percent solids by volume of their products or their spreading rates at a particular dry film thickness. If the latter is provided, the percent solids by volume can be determined with the Nomograph.

Remember that significant quantities of paint are lost during application, the amount varying with the method of application. Thus, a little more (e.g., 10%) is used than the theoretical amount calculated from the Nomograph.

EXAMPLE 1

What is the spreading rate at 2 mils dry film thickness of a paint containing 50% solids by volume, and how much will be needed to cover a surface area of 10,000 sq ft?

- When a ruler edge is placed at 50% on Column A and 2 mils on Column C, it crosses Column B at a point indicating a spreading rate of 400 sq ft per gal and a requirement of 2-1/2 gal to coat 1,000 sq ft. Thus, 25 gallons (2-1/2 x 10) would be required to coat 10,000 sq ft.

EXAMPLE 2

A paint supplier states that a particular paint will cover 200 sq ft per gal at 2 mils dry film thickness. What is the percent solids by volume?

- When a ruler is placed at 200 sq ft per gal on Column B and at 2 mils on Column C, it crosses Column A at a point indicating 25% solids by volume.

EXAMPLE 3

A contractor was required to coat the 30,000 sq ft interior surface of a tank with a 4 mils dry film thickness of paint containing 75% solids by volume. The Public Works inspector noted that his dry film thickness gage indicated an average thickness of about 3 mils and that sixteen 5-gallon cans of paint had been used. Did the contractor use enough paint to meet the dry film thickness requirement?

- When a ruler edge is placed at 75% on Column A and 4 mils on Column C, it crosses Column B at a point indicating a coverage of 300 sq ft per gal and a requirement of about 3-1/3 gal of paint to coat 1,000 sq ft. Thus, 100 gallons (30 x 3-1/3) were required for the job. Since only 80 gallons were applied by the contractor, the 4-mil dry film thickness requirement was not met, and the 3-mil reading of the inspector was verified.

SLIDE RULE

The Civil Engineering Laboratory is preparing a pocket-size slide rule that incorporates the Nomograph information. Qualified requesters can obtain a copy by contacting:

R. W. Drisko, Code L52
Civil Engineering Laboratory
Naval Construction Battalion Center
Port Hueneme, California 93043
Telephone: autovon 360-4658,
comm (805) 982-4658

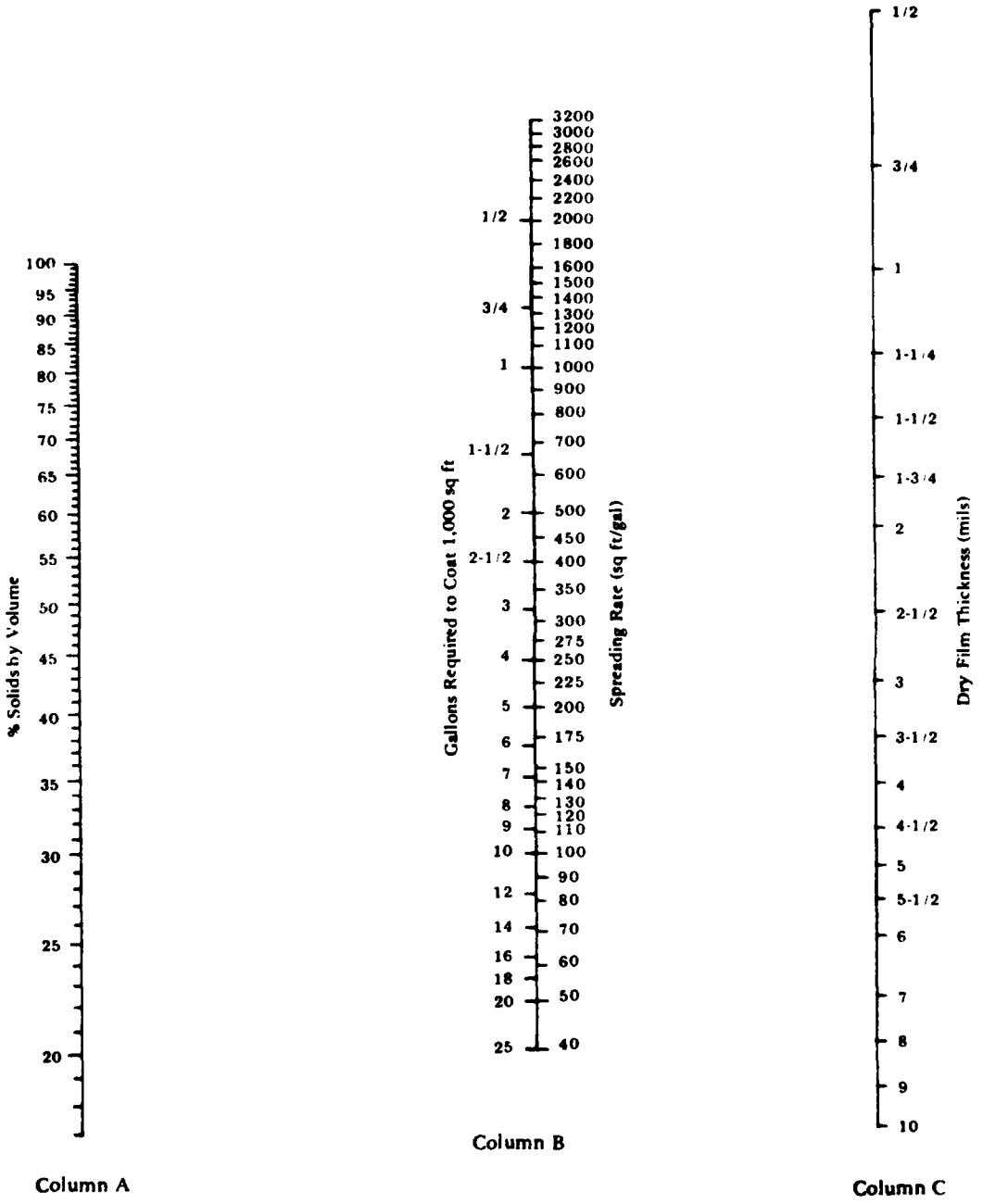
CEL CONTACT

R. W. Drisko (same address and telephone as given above).

NAVFAC CONTACT

Dr. H. G. Lasser, Code 0433B; tel: autovon 221-0464, comm (202) 325-0464.

Nomograph for Estimating Quantities of Paint



APPENDIX 6. SURFACE PREPARATION METHODS

Method	Specification	Specification	Equipment Used	Description and Comments
Power Tool Cleaning	SSPC-SP3	NACE Std TM-01-70	Power wire brushes, power impact tools, power grinders power sanders	Prepares metal for painting by removing loose mill scale, loose rust, and loose paint with power tools. It is intended that only loose mill scale, loose rust, loose paint be removed. This method is permitted where abrasives from blasting will damage adjacent surfaces or contaminate the adjacent equipment. Oil, grease, weld flux, etc. have to be removed by solvent cleaning prior to power tool cleaning.
Solvent Cleaning	SSPC-SP1	-	Solvents, emulsions, cleaning compounds, sprayers, rags, etc.	Removes oil, grease, soil and other contaminants from steel surfaces. Surfaces should be cleaned per this specification prior to using abrasive blasting equipment Note: Not all oil or similar contaminants will be removed by abrasive blast cleaning. Use of a clean white rag can be used to determine if solvent cleaning is necessary.
Commercial Blast Cleaning	SSPC-SP6	3	Conventional blasting where abrasive is propelled through a nozzle and is not recycled. Vacuum blasting-mobile closed cycle reduces dust and recycles abrasive.	Remove rust, mill scale and old paint except for slight shadows, streaks or discolorations caused by rust stain, mill scale oxides or slight, tight residues of paint remaining, if the surface is pitted. At least two-thirds of the surface shall be free of all visible residues and remainder limited to the light discoloration, slight staining or light

APPENDIX 6. SURFACE PREPARATION METHODS (CONTINUED)

Method	Specification	Specification	Equipment Used	Description and Comments
			Wet blasting water sand mixture propelled through nozzle, dust reduced, inhibitor added to reduce flash rusting Centrifugal blasting-closed cycle system where abrasive propelled by centrifugal wheels	residues mentioned above. After cleaning, the appearance should correspond with pictoral standards BSa2, CSa2 or DSa2 of SSPC-VIs1. Note: The different between commercial and brush-off blast cleaning (SSPC-SP7) is that dirt, rust scale, loose rust and loose paint are removed completely by brush-off blasting, but tight mill scale and tightly adhered rust, paint and coating are permitted provided that the abrasive blast pattern exposes numerous flects of the underlying metal fairly uniformly distributed over the surface.
Near-white Blast Cleaning	SSPC-SP10	2	As above	All dirt, mill scale, rust, corrosion products, oxides, paints or other foreign matter have been completely removed from the surface excedpt for very light shadows, very slight discoloration. At least 95% free of the above contaminants. After cleaning, the appearance should correspond with pictoral standard CSa21/2 of SSPC-VIS1.
White Metal Blasting	SSPC-SP5		As above	All mill scale, rust, rust scale, paint or foreign matter is completely removed from the surface and the surface is gray white, uniform metallic color. After cleaning, the appearance should correspond with pictoral standards ASa3, BSa3, CSa3 or DSa3 of SSPC-VIS1.

APPENDIX 6. SURFACE PREPARATION METHODS (CONCLUDED)

Method	Specification	Specification	Equipment Used	Description and Comments
High Pressure Water Spray Cleaning	-	-	Sprayer, 500-2,000 psi, cleaning compounds, inhibitor added to reduce flash rusting	Removes oil, grease, soil and other contaminants from steel surface. (See also comments on solvent cleaning). Also, chalk is removed from old paint surfaces.

APPENDIX 7. PERCENT RELATIVE HUMIDITY AND DEW POINT

Wet Bulb Temp Minus Dry Bulb Temp	Dry Bulb Temperature, Degrees F.													
	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1	90 *33*	91 *38*	91 *43*	92 *48*	93 *53*	93 *58*	94 *63*	94 *69*	95 *74*	95 *79*	96 *84*	96 *89*	97 *94*	-
2	80 *30*	83 *35*	85 *41*	87 *46*	88 *51*	89 *57*	90 *62*	90 *67*	91 *72*	91 *77*	92 *82*	92 *87*	92 *93*	-
3	74 *28*	77 *33*	78 *38*	80 *44*	81 *50*	83 *55*	84 *60*	85 *66*	86 *71*	87 *76*	88 *81*	89 *86*	90 *91*	-
4	65 *25*	70 *30*	72 *36*	75 *42*	75 *48*	79 *53*	80 *59*	81 *64*	82 *69*	83 *74*	84 *80*	85 *85*	86 *90*	-
5	60 *21*	60 *28*	64 *34*	68 *40*	71 *45*	73 *51*	75 *57*	77 *62*	78 *68*	79 *73*	80 *78*	82 *83*	83 *89*	84 *94*
6	48 *17*	52 *25*	59 *31*	62 *37*	65 *43*	67 *49*	70 *55*	73 *61*	75 *66*	76 *72*	77 *77*	78 *82*	79 *87*	80 *93*
7	40 *13*	46 *21*	51 *28*	57 *34*	60 *41*	63 *47*	66 *53*	68 *59*	70 *64*	72 *70*	73 *75*	75 *81*	76 *86*	77 *91*
8	30 *7*	40 *18*	45 *25*	51 *32*	55 *38*	59 *45*	62 *51*	64 *57*	66 *63*	68 *68*	70 *74*	72 *79*	73 *85*	74 *90*
9	20 *0*	34 *13*	40 *22*	45 *29*	50 *36*	54 *43*	57 *49*	60 *55*	63 *61*	65 *67*	67 *72*	68 *78*	70 *83*	71 *89*
10	10 -	28 *7*	32 *18*	39 *26*	45 *33*	49 *40*	53 *47*	56 *53*	53 *59*	61 *65*	63 *71*	65 *76*	67 *82*	68 *87*
11	- -	20 *0*	25 *13*	33 *22*	40 *30*	45 *38*	49 *45*	52 *51*	55 *57*	58 *63*	60 *69*	61 *75*	64 *80*	66 *86*
12	- -	10 -	19 *7*	29 *18*	35 *27*	40 *35*	45 *42*	48 *49*	52 *55*	55 *62*	57 *68*	59 *73*	61 *79*	63 *84*
13	- -	5 -	13 *0*	22 *13*	30 *24*	37 *32*	41 *40*	44 *47*	47 *54*	51 *60*	54 *66*	56 *72*	58 *78*	60 *83*
14	- -	- -	8 -	18 *8*	25 *20*	31 *29*	37 *37*	41 *44*	45 *51*	48 *58*	51 *64*	53 *70*	55 *76*	57 *81*
15	- -	- -	3 -	11 *0*	20 *15*	27 *25*	32 *34*	37 *42*	42 *49*	45 *56*	47 *62*	50 *69*	53 *74*	55 *80*

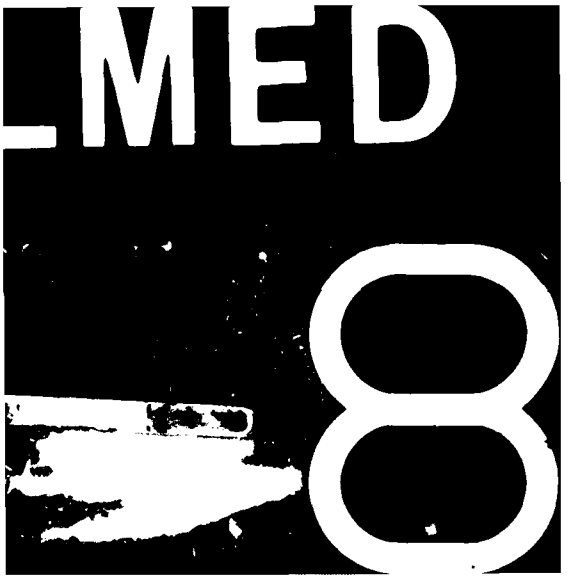
The number in the upper left-hand corner is the percentage of Relative Humidity (R.H.) The number in the lower right-hand corner is the Dew Point (D.P.) temperature in degrees Fahrenheit.

(The reverse of this page is blank)

INITIAL DISTRIBUTION

DDC-DDA-2	12
HQ AFESC/DEMM	10
HQ AFESC/TST	1
HQ AFESC/RDCF	2
HQ AFSC/DEMU	2
HQ AFLC/DEMU	2
HQ ATC/DEMU	2
HQ AAC/DEMUC	6
HQ MAC/DEMP	6
HQ PACAF/DEMU	6
HQ SAC/DEMH	6
AFRES/DEMM	2
HQ TAC/DEMU	2
HQ USAFE/DEEO	6
USAFA/DEVCT	2
NGB/DE	2
ANG Spt Cen/DE	2
AFML/MKP	2
AFIT/DET	2
HQ AFSC/DEE	2
AUL/LSE 71-249	1
AFIT/DES	2
USAE CERL	2
USAE WESGF	2
AFRCE-WR/PREHW	2
AFRCE-CR/CRNI	2
AFRCE-ER/S4	2
AFATL/DLODR	1

(The reverse of this page is blank.)


MED
8